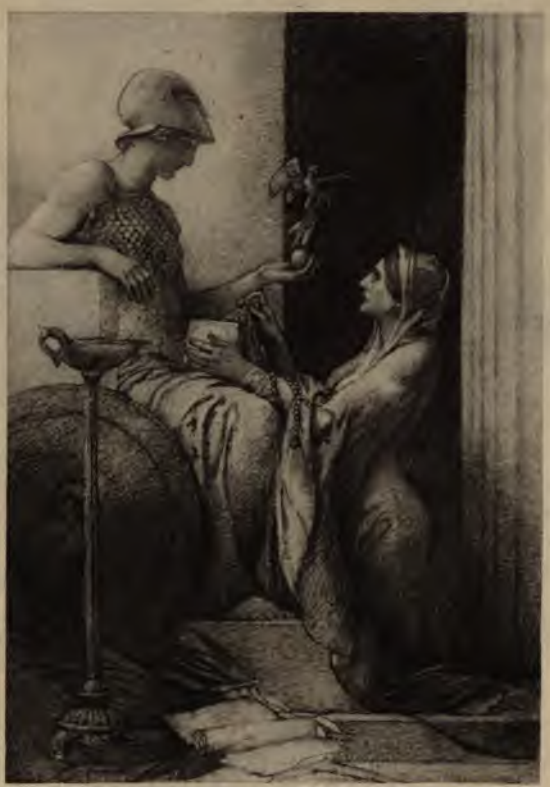
GEOGRAPHICAL AND GEOLOGICAL SURVEYS



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I. GEOGRAPHICAL.

THERE was perhaps never a time when so much general interest was felt in geographical work as at the present. Geography is decidedly the fashionable science; that is to say, not exactly geography, but geographical exploration, or, in other words, the investigation of the yet unknown portions of the earth. All the European nations are vying with each other as to which shall be the lucky country to secure the honor of being the first to solve some one of the few great geographical problems which yet remain to be worked out. England soon starts her expedition to the farthest North, roused to action in this direction, after many years of waiting, by the successes of the Americans, the Swedes, and the Austrians. The Germans themselves are attacking the one great question which Africa has yet to offer, namely, the tracing of the mighty Congo River to its source; while an Englishman is also struggling — unless he has already succumbed to some one of the many dangers of African exploration — to follow the connection of the lakes about which Livingstone's last work was done, and which he believed to be the head of the Nile, but which are now known, almost to a certainty, to belong to the hydrographical basin of the Congo.

Geographical societies and journals were never more numerous in Europe, or more fully patronized, than they now are; geographical papers find their way into the quarterlies and monthly literary magazines; and the sale of photographs of scenery is rapidly increasing, and tending powerfully to develop an interest in all peculiar features of the earth's surface, and

thus leading to the study of comparative geography. All along the base of the great European chain of mountains, the Alps, and on both sides of it, clubs have been formed for the purpose of uniting the means and energies of the many in the work of exploring the unvisited portions of the range, and of thoroughly working out the details of that which is as yet only partially known. These clubs number their members by the hundreds, and their published volumes already form a goodly series.

But while all this and much more of the same kind is being done, indicating a lively interest on the part of the general public in those explorations which have, as the result to be attained, some brilliant discovery, or the settlement of some long-discussed problem, there is, at the same time, another class of geographical work always in progress and on a vastly greater scale and of vastly greater importance than that of mere exploration, but in regard to which the general public knows almost nothing, and to which the popular magazines hardly ever allude. We refer, of course, to the great topographical surveys which are being carried on in every civilized country in the world, almost without exception, and which have for their object the preparation of topographical maps of the regions surveyed. Such maps have as their essential features absolute accuracy and minuteness of detail; and in this respect they contrast strongly with the work of preliminary exploration, or of reconnoissance, as this sort of surveying is commonly called. By the work of a preliminary reconnoissance, the character of the dominant physical features of a previously unknown region is ascertained, a laudable curiosity satisfied, and the nature of certain great commercial problems indicated. The topographical survey, on the other hand, presupposes a country already settled, and having made considerable progress in civilization, art, and commerce, so that land has acquired a high value, thus rendering accuracy in the determination of its subdivisions a matter of pecuniary importance. The object of the writer of this paper is, to explain in a popular way, without the use of any more technical terms than are absolutely necessary, the difference between geographical exploration, or reconnoissances, and topographical surveys,

and also to show what the latter are intended for, and what other civilized nations are doing in this line. It will then be interesting to inquire what the United States, either in their collective capacity or singly, have been able to accomplish towards a complete mapping of their own territory, and to give some hints as to what yet remains for us to do, that we may be put on a par with other countries with which we are much in the habit of considering ourselves, if not a little superior, at least fully equal in point of general intellectual development. The recent discussion of this subject in the Legislature of the State of Massachusetts has very clearly brought out the fact that, in regard to the value and cost of a topographical survey, or, in other words, of a correct map, our law-makers and a good part of the general public are very much in the dark; and it is hoped that a careful setting forth of some of the principal facts, by one who has had considerable experience in this sort of work, under United States and State authority, may be of interest, and perhaps useful when the subject is again brought up for discussion.

Let us first consider in what way the surface of the earth may be delineated, so that the result may be available for use. Almost every one, even the youngest school-boy, has some general idea of what a map is, and how by certain conventional signs it is the aim of the map-maker to place before the eye a miniature representation of some portion of the earth's surface, so that the relative position of its natural features, and of the artificial constructions or lines drawn upon it, may be taken in at a glance. These natural features are rivers, lakes, oceans, mountains; the artificial constructions are streets, roads, buildings, railroads, canals, and the like; the artificial lines which need to be indicated are the boundaries between States and towns, and other similar subdivisions of public and private property. That the above-mentioned features can easily be indicated on a map by lines, when their position has been carefully ascertained by instrumental measurements, is not difficult to understand; but there is another important element which needs representation, but which can at best only be approximately shown, and in regard to the best method of doing which there is no clearly established opinion. This element is the

vertical, or the relative elevation of different portions of the surface, which we know exactly whenever we can ascertain the precise height of every point above some fixed datum line, and which can also be approximately indicated by conventional symbols, as will shortly be explained. As this is an important question in topographical surveys, and one not well understood by the general public, some little detail in regard to it may be acceptable.

The most accurate and, in some respects, the most satisfactory way of representing the surface of any region is, to make a model of it; that is, a copy, in relief, necessarily on a greatly diminished scale, by which all the natural features, including the vertical element, are represented. Such models are usually first worked out in clay, just as a statue is copied by a sculptor from a living model, and then cast in plaster; or it may be carved in wood, or cut in cork, or made by piling sheets of cardboard cut into the proper shape upon each other. The data for such models must, of course, be obtained by measurements on the earth's surface, just as they would have to be if a map were to be made. These topographical models are particularly interesting and valuable when they include regions covered by lofty and precipitous mountains; and such have been made for parts of Switzerland which are visited by great crowds of pleasure-travellers. One, in particular, at Geneva, is wonderful in its execution, and is studied with the greatest interest by thousands who have climbed or tarried with delight under the shadow of the "monarch of mountains." Such models, however, are not only extremely costly, but they are, as may well be imagined, very cumbrous and entirely unsuited for transportation; neither can they be duplicated without great cost, unless limited to very small areas and made on a small scale. Hence they are rarely used, unless in peculiar and exceptional cases. Thus, for instance, in laying out a park for a large city, where the work is all to be done at once, and where the amount of money to be expended is very great in proportion to the area of ground used, and where the vertical element is of great importance, a model may often be of great assistance and indeed almost indispensable.

A photograph from a model gives, if taken with skill, under

a suitable illumination, a wonderfully clear idea of the relief of the surface. One such, of the vicinity of Mont Blanc, done by a French artist, on a scale of 1 : 80,000, lies before us, and nothing can be more satisfactory than the way in which the form of the surface is brought out by it, so that the eye can appreciate, at a glance, the exact relative position and elevation of the different parts of that great mountain mass. There are obvious reasons, however, why such models and photographs from models cannot come into general use. They are too expensive and not sufficiently portable, — portability being a very essential element in the use of geographical material. They are well adapted, however, for many purposes in teaching, and especially for conveying the first general idea of forms of surface to the young; they are also invaluable for illustrating geological structure in difficult and complicated regions.

Paper is the material on which the topography of a country is usually exhibited; and maps drawn upon paper, or else engraved or lithographed and then printed on that material, are in almost universal use. Hence a map means a representation on paper of some part of the earth's surface. It is easy to see that the first question to be asked in constructing a map is, What shall be its scale? or, What proportion shall it bear to nature? The school-boy's map of a hemisphere can hardly be more than a hundred-millionth of the natural size of the part of the earth which it covers, since it must show half the world on one small piece of paper; while the British Ordnance Survey map of the city of London is on a scale of one-thousandth, and occupies no less than 821 sheets. The former hardly does more than roughly indicate the boundaries of a continent, and of the principal states into which it is divided; while the latter exhibits the exact form and position of every building and division line of the land in the city. It will be easily understood that, in order that small objects may find room on which to be represented, a large scale must be adopted. It will also be not difficult to perceive that, in order to be able to prepare a map on a large scale, the preliminary topographical work must have been done with a proportionate degree of accuracy and minuteness of detail. The amount of time and money which has to be expended on a work of this kind is

proportionate to the amount of information it is intended to exhibit, and that this expenditure should be proportional to the importance of the area to be surveyed, that is, to its wealth and the density of its population, seems evident; and this would lead us to infer that the mostly thickly settled and richest countries must have the most accurate maps. This, however, is not uniformly the case; the general intelligence of the people, or their rulers, their habits of thought, and their appreciation of the practical use to which scientifically accurate work may be put, are also important factors, as will perhaps be discovered from what is said further on in these pages.

The determination of the scale to be adopted in any topographical survey means, then, the determination of the accuracy with which it is to be conducted, or the amount of detail to be put into the work. And it does not appear difficult to understand that, in a large country or state, it may be advisable to employ several different scales, or to proportion the accuracy of the survey to the importance of any separate division. A country like Belgium, of very small area, and with a population about equally distributed over its surface, would naturally be satisfied with much less variety of scale than would be advisable in Norway or Sweden, some portions of whose territory are very thinly inhabited. The same considerations would apply still more forcibly to our own country, great areas of which are almost worthless, or at best of no importance, except as having to be passed over in order to get in the shortest way from one part to another of our extended territory. It is true, however, that the same country usually requires maps on more than one scale, even if the survey is to be equally accurate over the whole area. For local details and for ordinary practical use, a map on a large scale is needed; but this requires that the work shall occupy a great number of sheets, on each of which only a small area can be given; so that, for general geographical purposes, where the eye needs to have before it at one time a considerable extent of territory, in order to obtain a connected idea of its physical features, it is necessary that a compilation on a reduced scale should be made, by which a considerable number of sheets are compressed within the limits of one. Thus in the Ordnance Survey of Great Britain, maps

on both the six-inch and the one-inch scale are furnished, and are equally in demand.

Having determined the degree of accuracy with which the work shall be prosecuted and the scale or scales which shall be used, it is necessary to decide how the vertical element, already alluded to, shall be exhibited. And this is a matter of some difficulty, and one in regard to which there have been formerly considerable differences of opinion. We have seen how an idea of the relief of the surface can be given by means of light and shade, in the case of the photographic copy of a model, which is wonderfully effective in conveying the idea of differences of elevation, the effect depending exclusively on the distribution of the light and shade caused by the obliquely falling rays of the sun; were a photograph to be taken from such a model, with the rays descending vertically on it, the illusion or perception of the relief of the surface would be entirely lost. The same thing can be done, although less perfectly, by a skilful handling of the brush on paper, or by the lithographer on the stone with the crayon, giving a sort of bird's-eye view of the region to be mapped; and, in the hands of a thoroughly artistic worker, with an eye for topography, much may be accomplished in this way. This method of indicating the relief of the surface is used now to some extent, especially in maps of regions covered by mountain ranges, where a considerable area is to be shown at once, and where, from the nature of the country, as well as from the necessarily small scale adopted, it is not expected that anything more than a general idea of the topography can be given. The map of the Thian-Schan range, recently published by Petermann, and that of California and Nevada, by the Geological Survey of the first-named State, are good instances of the application of this method.

But for an accurate topographical survey, where it is desired and expected that a close approximation to the vertical element shall be obtainable from the map, and not merely a picture conveying a general idea to the mind, other methods have to be adopted. An approach to accuracy is made by shading the hills by means of short, straight lines, or *hachures*, as they are generally called. Most of our ordinary geographical maps

have the position and direction of the mountain ranges delineated on them by these hachures, which, as ordinarily used, are only a sort of conventional symbol, intended to indicate vaguely the existence of a hill or ridge, or series of ridges, and too frequently having a perverse resemblance to a cluster of caterpillars crawling over the surface of the map. The original idea of these lines is, that they indicate the course which a stream of water would take in running down the side of the range, in the line of most direct descent, thus furnishing a clew to the direction of the slope. Many years ago a German topographer, named Lehmann, gave a more precise value to these hachure lines, by proportioning their thickness to the angle of slope of the surface they were intended to represent. Thus, by this system the steeper portions of the slopes appear on the map in darker shade than the less inclined surfaces, so that the relief is indicated something in the same way as if the hill-shading were done by the brush, in the manner indicated above, while the eye can determine from the thickness of the lines employed, although only approximately, the angle of the slopes. Many beautiful maps have been made, according to this system or some modification of it. Thus the Dufour map of Switzerland, as it is called, in which Lehmann's method, modified by the introduction of an oblique illumination, was used, is a masterpiece of the chartographic art.

Topographical maps were formerly made, in Europe, almost exclusively for the purposes of military defence, that is, to guide generals in arranging the movements of their armies; and it is only in later years that the civil uses of these surveys have become more prominent. Hence, as the demands of commerce, agriculture, and manufactures have begun to be heard more frequently and louder than those of war, more accurate work has been required, and the insufficiencies of the hachure method for details have become evident. The angle of a slope was the important element when the movement of artillery up or down it was the question to be decided; but the civil engineer, who has the more peaceful object in view of building a railroad or cutting a ditch, wants a section of the line he has to pass over, or, indeed, sections of many lines, that he may choose the one best adapted to his purpose; and

he wishes to know the absolute height of each point in that section above the sea-level, or some other datum line, which may have been selected as the plane to which all the heights should be referred. This is done by means of contour lines drawn upon the map, so as to connect points having the same elevation above the datum line, and at greater or less vertical distance from each other, according to the amount of accuracy and detail which may be required. The steeper the slope the nearer to each other the contours will fall, so that an increased steepness of the ranges will be indicated to the eye at once by the crowding together of the lines, thus reproducing, in a measure, the effect of the brush-shading spoken of above. This method may be understood more easily by those unaccustomed to maps made in this way by using a simple illustration. If we suppose in a lake a mountainous island, a thousand feet high at its highest point, to be sunk by ten successive stages of one hundred feet each, then at each stage of the sinking the water will meet the land and mark a line upon it connecting all the points which are respectively 100, 200, 300, and so on, feet above the original level of the lake. The lines thus marked by the rising edge of the water would be exactly in the places which contour lines accurately run at vertical distances of 100 feet would occupy. Any person looking at such contour lines would see at a glance what portions of the island were 100, 200, and so on, feet above the lake level; and if the slopes were pretty regular, he would be able to get a good idea of the relative heights of all the other points intermediate between those lines. The advantage of this system of contouring, as it is called, is, that from any map on which such contour lines are indicated a section can be drawn at once, which will more or less accurately reproduce the slopes and exhibit the elevation of all points on that section. And such sections are invaluable and, in fact, indispensable, in operations connected with the building of roads, railroads, ditches, canals, and engineering work of all kinds. The degree of accuracy with which such sections can be drawn depends on the distance apart of the contours. In cases of great importance, and over limited areas, they may be fixed at a distance of two or three feet apart vertically. In ordinary

topographical surveys they may be drawn at distances of from twenty to a hundred feet or more, according to the nature of the country and the contemplated accuracy of the work.

A good topographical map of any region, therefore, will have indicated upon it all natural objects, such as lakes, rivers, and smaller water-courses; artificial ones, namely, boundaries of fields, enclosures, roads, houses, etc.; and, besides these, it will exhibit to the eye and furnish for use the vertical elevation at all points above the level of the sea, this being usually chosen as the datum line from which the altitudes are reckoned. And by "level of the sea" is usually meant mean low tide, or else the mean between mean low and mean high tide.

Thus far we have chiefly confined our remarks to the methods by which topographical information is brought into an available form, so as to be presented to the public on paper. And, indeed, many persons are so little acquainted with this kind of work, that they imagine the plotting of the survey and putting it into the form of a map to be the essential thing. This is the case indeed with most or all school-maps and with many others which are offered to the public, especially in this country; they are simply compilations and workings over of other people's labors. But wherever an accurate map exists, there must have been done by somebody, and at somebody's expense, in the field, an amount of labor, and that of a kind demanding the highest degree of skill and immense patience, compared with which the mere plotting and engraving of the work is comparatively insignificant. Few persons, except those themselves professionally engaged in such surveys, have any idea of the amount of labor, and of course of time and money, required by a thoroughly accurate topographical survey, even if the area over which it extends be one of moderate dimensions. It may seem an easy matter to measure a line on the ground of half a dozen miles in length; and so it is, if the region be level and it be a matter of no consequence whether the measurement be correct, provided it comes within a few inches of the truth. If a traveller wished to know the distance from one town to another, he would consider it quite a superfluous degree of accuracy that he should be informed to the nearest rod; while in

buying a piece of land in a large city a difference of half an inch in the width would be a matter of importance. Now, while most of the determinations of position from which the skeleton of a map is made are done by means of the measurements of angles and not of lines, there must be, to start with, a base measured somewhere on the surface, as a necessary preliminary to the triangulation, or the angular measurement of the net-work of triangles which covers the region to be mapped, and which forms the frame, so to speak, into which all the details are to be fitted. This base line must, however, be measured with the utmost precision, even down to the smallest fraction of an inch; for any error made at this preliminary stage of the work would be many times magnified as the work was extended from its original starting-point, and the value of the whole would be destroyed. It would be hardly possible to convey to the uninitiated an idea of the skill which has been bestowed on the construction of the instruments with which this base measuring is to be done, and of the patience and care with which they must be used. With the apparatus devised by Bache and Würdemann, and used on the United States Coast Survey work, distances are measured with such precision that the probable error in one mile is only about two hundredths of an inch. And to show the accuracy with which the work may be extended from a measured base by triangulation, it may be stated that a line 5.4 miles long on Chesapeake Bay was connected in the primary triangulation of the United States Coast Survey with a measured base of 8.7 miles on Long Island, the two being 208 miles distant from each other in a straight line. Yet the measured length of the base of verification on Chesapeake Bay agreed with its calculated length, as determined by computation of thirty-two connecting triangles, within four inches. Thus the same degree of accuracy is required in the angular as in the linear measurements, the instruments required for each of them being alike delicate and ingenious in their construction and requiring the most refined skill for their handling. As a general rule, the sides of the primary triangles should be made as long as possible; that is, the two ends must be as far apart as vision aided by powerful telescopes can be extended. The object sighted at one end of

the line is a beam of the sun thrown by a mirror directly into the axis of the telescope at the other end. By this beautiful contrivance the stations may be in some cases as much as a hundred miles distant from each other, while the average length of the sides of the primary triangles in the Ordnance Survey of Ireland is fully sixty miles. This preliminary work is called the main or primary triangulation, and the points fixed in position by it are determined with all the precision that is possible by means of the most refined observations made with the largest and most perfect instruments that can be constructed. Further approaches to absolute accuracy are made by means of frequent repetitions of the observations, which are afterwards examined by the aid of mathematical analysis, so that every possible source of hidden error may be detected. It is to the points thus determined by means of the primary triangulation that the rest of the work is connected and referred; a less degree of accuracy being required for the secondary and tertiary triangulations, because these can always be checked by means of the primary stations. This more detailed work is simply a dividing up of the large triangles into smaller ones, each step in the operation having as its object the fixing of the position of more points; and this is carried on until the whole surface of the country has been cut up into triangles of suitable dimensions. In the British Ordnance Survey over districts where the scale of six inches to a mile is to be used, two points have been fixed by the triangulation on every square mile; and where the scale is five feet to a mile, sixteen points have been determined on the same area. Into the framework thus elaborately prepared the minute details are fitted, and this is done of course by the aid of comparatively small instruments, the use of which requires much less skill than is needed when the larger ones have to be employed. The plane-table is almost exclusively used on the Continent of Europe for the detailed work; and by means of this instrument the work is plotted on the field, and only needs to be inked in afterwards. By the aid of photolithography these plane-table sheets can easily be multiplied to any extent; and it is one of the greatest advances recently made in topographical surveys, that the original work can thus be

cheaply duplicated, and that all land-owners can have without delay copies, on the largest desired scale, of the original surveys of their own property.

Having thus explained as concisely as possible the nature of the operation of a topographical survey, it will be desirable to refer briefly to what is being done in Europe in the way of preparing accurate maps of the different states, before passing on to a review of our own needs. But space will not admit of our doing anything more than merely to indicate, for a few of the most prominent countries, the scope of their topographical work; the simple catalogue of the great maps in process of publication in Europe, made as concise as possible, would occupy many pages of this Review.

Let us begin with Great Britain, which, including Ireland, has an area of nearly 111,000 square miles, and where the topographical survey has been going on since about 1784. The scientific work is partly performed by officers and privates of the Royal Engineer Corps,* and it is officially known as the "Ordnance Survey." Its total cost, from 1791 to the end of 1864, including the military pay of the men employed, was £2,991,624, and may be estimated to have been up to the present time about £4,200,000. The scales adopted are numerous, and in case of some cities are as large as five and even ten feet to the mile. The principal published maps, however, are on two scales, one of six inches, and the other of one inch to the mile (1:10,560 and 1:63,360). Of England the map on the one-inch scale was begun in 1784 and finished in 1869; but the projection employed in it was defective, and it is in other respects not up to the present requirements of the country, hence it is now in process of working over and republication. Of the area surveyed on the six-inch scale, 24,877 square miles had been completed in England and Wales, and 27,829 in Scotland, up to the end of 1873. Ireland, on the same scale, was entirely finished in 1845, and all the sheets, 205 in number, published without, and about half with, the hill-shading. Besides the maps on the six-inch and one-inch scale, plans are furnished of any district as called for,

* 382 military, including officers, and 1,446 civil assistants were on the Ordnance Survey staff in the year 1872.

on the scale of 1 : 2,500 (about 25 inches to the mile), made by photozincography; but these are not necessarily engraved or published. The map of London is on a scale of 1 : 1,000, and is comprised in 821 sheets. The various publications of the Ordnance Survey are sold in single sheets as wanted, at very moderate prices; but so great is their number, that the cost of a complete set, as far as already published, amounts to over £ 3,000. A great deal of work is prepared for the use of the government on very large scales; but it is chiefly the six-inch and one-inch maps which are of importance to the general public. At the present rate of progress it will require about ten years to complete the survey.

In Belgium the scale adopted is 1 : 20,000, the area of the country being about 10,000 square miles; 450 sheets will be required, of which 137 were published up to the end of 1873; the contour lines are drawn at distances of one metre, every fifth one being indicated by a heavier line; the sheets are lithographed and printed in colors, the rivers and lakes being in blue, the lettering and roads in black, the meadows and forests in different shades of green, the buildings in brick-red, and the gardens in carmine.

In Prussia, since 1849, new and more perfect methods have been introduced into the topographical surveys; the plane-table sheets are now published on a scale of 1 : 25,000, and with contour lines at distances of 5, 12½, or 25 feet, according to the nature of the country. The publication of the plane-table sheets was commenced in 1868, and in 1873 120 had been issued. There has also been, since 1841, a general map in process of publication, on a scale of 1 : 100,000, which will be comprised in some 400 sheets, of which nearly all are issued. These are engraved on copper and have the topography, or hill-shading, indicated according to Lehmann's system, as modified by General Müffling.

In Baden, the new map was commenced in 1874, on a scale of 1 : 25,000, and with contour lines at 10 metres' distance. The work is mainly a revision and correction of older surveys, and is expected to occupy six years, at a cost of about 80,000 florins.

In Saxony, the original survey was commenced in 1780 and completed in 1806 on a scale of 1 : 12,000, the area of the king-

dom being 5,600 square miles. A topographical map was issued in the years 1837–1860, in 22 sheets and on a scale of 1:57,600. A new map was determined on in 1860, on a scale of 1:100,000, and it was completed in ten years; there are two editions of this, one with the line-work only and the other with the hill-shading.

Having now shown what is doing in some of those European states which are, comparatively speaking, rich, densely inhabited, and with moderate areas of territory, let us turn to the consideration of some countries which have only a thinly scattered population and a large area. Russia, for instance, with its enormous territory, just about twice the size of that of the United States, Alaska included, has been for many years actively engaged in prosecuting geographical surveys. The map of Russia in Europe, embracing about 2,100,000 square miles, has been under way since 1857, and will be embraced in about 700 sheets, of which 454 had been published in 1872. This is on a scale of 1:126,000. The military map of Poland is on the same scale, and is embraced in 57 sheets, all of which are published. Special maps of the Caucasus have also been completed; and, recently, a map of Central Asia. Norway has an area of 123,300 square miles, and a population about that of Massachusetts; that is, our own State is eighteen times more densely populated than Norway. But this comparatively poor country has set itself on having a good topographical map on a scale of 1:100,000, and which will occupy over 200 sheets. Those which have already appeared have been highly praised for their execution by competent judges; they are printed in chromolithography, like those of Belgium. Sweden also, very similar to Norway in respect to area and density of population, has her topographical maps on the same scale (1:100,000), and the work is already nearly half completed, the first sheet having been published in 1860.

We have thus given, necessarily in a very concise manner, some idea of the scope and methods of topographical surveys; and, before going on to consider what has been done in this country, it will be well to say a few words on the methods employed for mapping regions where, owing to the nature of circumstances, only imperfect work can be done, as in the first

rough reconnoissance of an uncivilized region, or where the poverty and ignorance of the people have not yet allowed them to grasp the idea of a geographical map, and where consequently all such work has to be done for them by other nations. In parts of Central Asia the topographer must get what information he can, without the use of instruments, and not even exhibiting a note-book, but trusting almost exclusively to memory, or to a few hasty lines pencilled at moments when the jealous vigilance of the natives might accidentally be relaxed. Most of our knowledge of the geography of Central Africa, such as it is, has been got almost without instrumental assistance. In such cases distances have to be guessed at, or roughly determined by keeping an account of the time employed on the march and estimating the pace of the animals ridden or driven. An odometer fastened to a wheel of the vehicle gives a still better approximation, when the ground is not too rough. Schweinfurth, the eminently successful African traveller, having lost his watch, with untiring patience counted his steps for six consecutive months, thus getting a quite respectable basis for a plotting of the region traversed. The direction is kept by means of the magnetic compass, and a great deal of valuable information has been obtained by these most simple means for determining the relative position of the various objects noted. The geographical traveller, however, usually has at his command the means of more or less accurately checking his daily sketches of the country, by means of astronomical observations. One element of geographical position, the latitude, is easily determined with portable instruments, for the use of which but little skill is required; but the fixing of the longitude, even if only to within a few miles of the truth, is a matter of considerable difficulty. To determine the longitude, so that the result may be depended on as being not more than two miles in error, requires a long series of observations made with skill, and with instruments which can hardly be called portable. But within the last few years the construction of numerous lines of the magnetic telegraph, some of which run through quite uninhabited regions, as, for instance, the one traversing Australia from north to south, has made the accurate determination of longitude comparatively easy in many places where before it was

almost impossible, and has thus rendered great services to geography. The chronometer, which does such excellent service at sea, is of very little use to the traveller by land, except for rough work, since the inevitable jolting consequent on moving about in wagons or on horseback is fatal to the accuracy of its going.

With these preliminary remarks, which, it is hoped, will make that which follows intelligible to the general reader, we pass to the consideration of the progress in geographical work in our own country. And, first, we have to call to mind the extent of our territory and its very diversified character; and, with but slight consideration, it will be evident that different portions of our vast area are very differently situated as regards their chartographic necessities. Without taking Alaska into consideration, we have, roughly speaking, three millions of square miles of territory, embracing almost every conceivable variety of soil and climate, and including the grandest expanse of fertile plain and the roughest and most inaccessible ranges of granite pinnacles. Valleys meandering among low forest-clad ridges, and offering every inducement for settlement and cultivation, are present in one part of our country; while, in another, we have precipitous cañons, cut through the solid rock to the depth of thousands of feet, and from the edges of which one may have in full sight an abundance of wholesome water, and yet die of thirst, from the sheer impossibility of climbing down the almost vertical walls by which the stream of life-giving fluid is hemmed in. The Atlantic Slope, the Appalachian Ranges, the Mississippi Valley, the Plains, the Great Basin, the Pacific Slope, — these all have their peculiarities of soil and climate, and are suited to invite settlement in very different degrees; so that, while portions of our territory are already densely populated, others are uninhabited, unless by a few half-starved, wandering Indians, and will always remain so. It is evident, therefore, that no one system of topographical work would be applicable equally to all parts of the country; but that a judicious discrimination will have to be exercised in selecting scale and methods best adapted to the varying wants of each particular section. It must also be remembered that, in the conflict between State and United States authority, different parts of the country are very differently situated as

regards their rights and duties in this very matter of topographical surveys, as will be explained more fully when speaking of the United States Land Surveys. No one can doubt that Congress, if it saw fit, could organize and cause to be conducted to completion a topographical, or a combined topographical and geological, survey of the whole area of our country; but this has not been done, nor is there reason to suppose that it will be. Something has been accomplished, however, and that must now be examined. And we will speak first of the preliminary reconnoissances and surveys which have been undertaken, mostly by the authority of Congress, and in the region west of the Mississippi, because nothing of this sort has been done, or needed to be, in the Atlantic States, or in the region east of that river, where the "Land Office Surveys," to be noticed further on, have long been established.

Twenty-five or thirty years ago the western half of the North American continent, north of Mexico, with the exception of its coast line, roughly laid down by the old Spanish and English navigators, was known to geographers only in the vaguest possible way. The courses of the principal streams — the Missouri, the Columbia, and the Colorado — had been approximately mapped, it is true; but the details of the interior were not much better known than is the centre of Africa at the present day. Up to the time of the acquirement of California from the Mexicans by the United States, progress in the exploration of this vast region had been extremely slow. Our government had little idea how soon the Pacific side of the continent was to become an important part of our Republic. From time to time, since the beginning of the present century, small expeditions had been sent out to explore its trackless wastes; the daring and restless fur-traders had wandered vaguely over regions which it seems incredible that they should have had the audacity to reach; and, from their rough notes and unskilled observations, maps had been put together in which the outlines of the physical structure of the country began dimly to appear. As late as 1826, however, our maps represented a narrow chain of mountains as traversing our whole territory from north to south, in longitude 105° to 110°, and dividing the waters flowing into the Atlantic from those

tributary to the Pacific. Besides the Columbia and the Colorado, three other great rivers were indicated as heading in the Rocky Mountains, and running directly west to the Pacific. These were called the Buenaventura, the Timpanogos, and the Los Mongos. Thus the existence of the most striking feature of our western geography — the Great Basin — was entirely unsuspected at that time.

The memorable expedition of Captains Lewis and Clarke, in 1804 to 1806, — the first important one ordered by our government, — had made known the position of the Upper Missouri and the Columbia; and the excursions of the Spanish-Mexicans, from the southwest, had furnished us with the materials for indicating the course of the Colorado with some approach to accuracy; but all the region between this river and the Columbia, comprising an area of about half a million of square miles, was vague and indefinite. Even Lewis and Clarke, who were generally extremely careful and accurate in their work, considering the means at their command and the circumstances of the party, were deceived by the size of the Willamette at its mouth, and represented it on their map as heading far to the east in Salt Lake; while, in reality, its course is really parallel with the Pacific coast, and at but little distance from it.

Major Pike was the first American explorer who reached the sources of the Colorado, and the second who crossed the divide between the Atlantic and the Pacific Oceans. This was in the years 1805 – 1807, just after the return of Lewis and Clarke. In this expedition — made to explore the sources of the Arkansas — Pike struck a large stream, which he supposed at first to be the Red River, and afterwards the Yellowstone (so vague was the knowledge of our geography at that time), but which is now known to have been the source of Grand River, the southernmost of the two great branches which unite to form the Colorado.

Humboldt's map, accompanying his great work on New Spain, was compiled and published soon after the explorations of Lewis and Clarke and Pike had been completed, and contained all that had been ascertained by the Spanish-Mexican explorers about the territory now included within our

domain as far north as latitude 42°. This map was less in error, in some important particulars, than many others published years later, for it did not show any rivers heading in the Rocky Mountains and running due west to the Pacific. Great Salt Lake had been indistinctly recognized at that time; and a body of water with that name, the limits of which were not defined, is given on Humboldt's map; while the existence of another large one farther north, and called Timpanogos, is indicated as doubtful: this latter one was laid down on much later maps, as being the head of the Los Mongos River. The name Los Mongos has disappeared from our maps, but that of Timpanogos * still exists, and is given to a small stream running into Utah Lake.

Major Pike was the discoverer of a prominent mountain, called by his name, at the base of which he camped, and for which he seems to have entertained an almost superstitious reverence. He says that "it is so remarkable a mountain as to be known to all the savage nations for hundreds of miles around"; and he did not attempt to climb it, for "no human being could have ascended to its pinnacle." Its elevation he estimated at 18,851 feet. This mountain for some time gave the name to what is now the State of Colorado; and when the discovery of gold began to draw a crowd of emigrants in that direction, they were universally known throughout the West as "Pike's-Peakers." The elevation of this point is now known to be a little over 14,000 feet, and a United States Signal-Service station has been established on its summit.

The expedition of Major Long, in 1819, 1820, to the head of the Platte, was the first one sent out by our government, equipped in anything like a respectable manner, and provided with scientific observers and naturalists, charged with the investigation of the geology and botany of the region traversed. One of the high peaks of the Rocky Mountains, and the only one visible from the line of the Pacific Railroad, bears the honored name of Long. The same officer afterwards made the first exploration of the Minnesota or St. Peter's River. The sources of the Mississippi were roughly mapped by Lieutenant Allen in 1832.

* "Timpan" is the Shoshone word for *rock*.

Up to this time we were still without any definite knowledge of the region between the Colorado and the Columbia. The existence there of a large salt lake was vaguely known, and had been for a hundred and fifty years, much that was mythical being connected with it by various geographers. There is little doubt that it had been seen and navigated by American fur-hunters as early as 1824; but they never thought or cared to publish to the world the facts they had observed. Captain Bonneville, of the United States Army, was the first educated man to visit this remarkable interior lake, and to ascertain and make known that there was a vast region, between the Rocky Mountains and the Pacific coast, of which the waters had no drainage to the sea.

Bonneville's expedition was not under the patronage of the government; he obtained, however, leave of absence from the army as well as leave to pay his own expenses, and to furnish himself with instruments; and, because he stayed away somewhat longer than was expected, he was dismissed the service. Indeed, Bonneville seems to have been a man very ill-used by fate; for his work was forgotten or ignored by subsequent explorers, notably by Fremont; the names he gave to the prominent features of the country which he discovered were never adopted, and not even the influence of Washington Irving was sufficient to make the intrepid explorer's name stick to the lake he was really the first to make known to the world. He never even got so far as to be a candidate for the Presidency; neither was he called the "Path-Finder"; that name he must have dropped somewhere on his route, for the one who followed him picked it up.

Bonneville went entirely around the Great Basin, going out by the Valley of the Humboldt, which he called Mary's River, and returning by the old Santa Fe trail, which was the one used by the native Californians in travelling from the southern Spanish settlements on the Pacific coast to Santa Fe. His narrative, edited by Irving, was published in Philadelphia in 1837, in two volumes, with two maps. It does not appear, from anything that Fremont published, that this work had ever come under his notice.

Nicollet, a Savoyard, who came to this country about 1831,

and who was a skilful practical astronomer, did a good amount of valuable geographical work in the years 1836–1843, first on his own private responsibility, and afterwards in the employ of the government, and chiefly about the sources of the Mississippi. The region he explored, and was the first to map approximately, has since been surveyed by the United States Land Office and has become the flourishing State of Minnesota; but the value of Nicollet's service, as one of the pioneer geographers of the country, cannot be forgotten. He was the first explorer in this country who used the barometer with skill for the determination of elevations in the interior, and it was as his assistant that Fremont learned the use of portable astronomical instruments.

We have now mentioned all the most important reconnoissances and explorations, having for their object the development of the geography of the Far West, previous to those of Fremont. With this energetic and intrepid, if not always judicious, explorer, may be said to have commenced the first systematic investigation of the geography of the region west of the Rocky Mountains. Thanks chiefly to the influence of his father-in-law, Colonel Benton, Fremont, whose explorations began in 1842, was well fitted out by the government both as to men and instruments, and he had a great advantage over all previous workers in that field, in that he was accompanied by a skilful assistant, Charles Preuss, so that he could devote himself to the astronomical observations, while Preuss attended to the delineation of the topographical features of the country, — a kind of work in which he was highly proficient. Fremont made several expeditions across the mountains, in the fourth and last one of which the party suffered terribly, having been overtaken by winter snow-storms, so that, as is universally believed in California, they were driven to actual cannibalism.

It is only the three first expeditions which are important, or of which any account has been published. The first was in 1842, up the Platte to the Sweetwater, then to the Wind River range, and back down the North Platte. The reports of this and the next expedition — that of 1843 and 1844 — were issued together, and have been much more widely circulated and read than any other geographical documents of the kind ever

published in this country. This second expedition, in which Fremont supposed that he had discovered the "Great Basin," in which, as we have seen, he was anticipated by Bonneville, was really a grand triumph over every kind of obstacle; it was, however, less remarkable than that of his predecessor; since, while the one was accompanied by a large and well armed party, provided even with artillery, the other was only one of a small band of volunteer explorers, more than half of whom were swept off in one battle with the Indians. Fremont's party started from Kansas in May, 1843, on the second expedition across the mountains. They followed up one of the branches of the Platte, through the Black Hills, up the Sweetwater, to South Pass, — then generally supposed to be the proper line for a railroad across the continent, — thence by a circuitous route to the Boise River and the Columbia; thence on the east side of the Cascade Range, by Pyramid and Mud Lakes, down the eastern edge of the Sierra Nevada, which was crossed in midwinter after much suffering and many dangers. At the great ranch of Sutter, one of the survivors of the Swiss guard of Charles X., who had settled near the junction of the American River with the Sacramento, Fremont was hospitably received; and, after recruiting his party, he started on the return trip, going south to the head of the Tulare Valley, and then recrossing the Sierra, and back through the southern portion of the Great Basin to the Parks of the Rocky Mountains, and down the Arkansas to the starting-point, which he reached after fourteen months of almost continuous journeying.

Of the next expedition, in 1845–46, the results have never been published; but in 1848 a map was issued, accompanied by a pamphlet entitled "A Geographical Memoir upon Upper California." This map was the first representation of our Western territory which made anything more than a distant approach to correctness. It gave at least a tolerable general idea of the most striking geographical features of the region: the Parks, the Sierra Nevada, the Great Basin, with its nearly parallel north and south ranges; the great Lava Plain of Oregon; the dry plateaux of Southern Utah and California: these were all indicated with more or less clearness.

And now, just at the close of Fremont's career as an

explorer, came an event which had a lasting influence in a variety of directions, and among others in that of the geography of the West. The Californian gold excitement, and the consequent rush of emigration across the plains to the Pacific shore, seemed all at once to bring that region close to us which had been before so distant and little cared for. The establishment of a line of steamers by way of the Isthmus of Panama to California led to the building of a railroad to connect the two oceans at a convenient point. Soon communication by rail through the heart of the continent began to be talked about, but at first as something only possible perhaps in a distant future. The matter was more and more discussed, and then Congress was appealed to, and it was urged that a survey should be ordered for the purpose of ascertaining the most feasible route. Appropriations were made for this purpose, and several surveying parties organized under the direction of the Secretary of War, officers of the United States Engineer Corps being placed in command of them. The work was continued from 1852 to 1857; and in addition to the reconnoissances made with a special view to railroad routes, there was considerable topographical material collected, and quite a number of naturalists were also employed in investigating the geology of the region traversed, and in making collections in all departments of natural history. The routes explored were near the forty-ninth, forty-seventh, forty-first, thirty-eighth, thirty-fifth, and thirty-second parallels. The work was hastily, and some of it carelessly, done, most of the persons employed having had little or no experience in topographical or geological surveys; but, on the whole, the results formed a large addition to our previous stock of knowledge; and the collections, especially, were of great value as giving the material for making out a pretty full account of the distribution of animals and plants over the vast area traversed by the exploring parties. Thirteen ponderous quartos were issued within two or three years after the field work had been completed, and are familiar to all — as to their exterior, at least — as the "Report of the United States Pacific Railroad Surveys." Maps were made by each party of the region embraced within the area of its explorations; and from them, and all

other available sources of information, a general map was compiled under the direction of Lieutenant (now General) Warren. This map has been so much altered and worked over at the United States Engineer Bureau, since its first appearance in 1857, that it has but little now remaining on it of the original material. Its scale is about forty-seven miles to an inch, and it was compiled and drawn with great care and skill by Mr. Freyhold, much difficulty having been found in reconciling the erroneous and conflicting determinations of longitude, as is fully set forth in the elaborate and valuable memoir by General Warren which accompanied the map in question. Indeed, it was especially with regard to longitudes that the United States Pacific Railroad surveys were deficient, there being but few good instruments taken into the field, and fewer still of good observers who went with them. A delay of a few months in beginning the work, supposing the interval to have been devoted to preparing suitable instruments and training observers in their use, would have added greatly to the value of the results. As it happened, curiously enough, not one foot of the ground explored by these parties for a transcontinental railroad is passed over by the line as it has actually been built, excepting the valley of the Humboldt River, which was part of the regular emigration route at that time, and almost an unavoidable link between the Atlantic and Pacific.

The Mexican and Northwestern boundary surveys have accurately fixed the lines which separate us from British territory on the north and Mexican on the south. The former was completed in 1856, and the latter much more recently. The results were of little value from a geographical point of view, since the topography was worked up only in the immediate vicinity of the lines surveyed. A Report on the Mexican Boundary Survey was published by our government, in two volumes, and illustrated without regard to expense, the most valuable portion of it being that relating to the botany of the region adjacent to the line. No full report has ever been issued with regard to the running of the Northwestern boundary, nor have any of the maps been published. The line has been established and marked, and left to time and the Indians to take care of. So with other government surveys of lines dividing

the individual States. They have not been creditable to the country, either in the methods or accuracy of the work; neither have they added much to our knowledge of the geography of the country, and rarely has anything been published in regard to their results. The work done on the line between California and Nevada is one of the worst instances of this putting of costly and important undertakings in the hands of incompetent men.

The expedition of Lieutenant Ives up the Colorado River, made in 1857, 1858, developed interesting facts in regard to the physical geography and geology of that very remarkable region; but the chartographic portion is very defective, the work having been of the most sketchy description.

At the time of the commencement of the War of the Rebellion, there were several reports of geographical explorations in the possession of our government, whose publication was delayed by the troublous condition of the times, and which appear now to be buried in the archives of the departments at Washington, and destined never to see the light. One of these reports was an important one; it related to an expedition under the direction of Colonel Macomb, having for its object the exploration of the San Juan River, one of the principal affluents of the Colorado on the south side. Another was that of General Warren's reconnoissance, in 1855–1857, in Nebraska and Dakota; and still another contained an account of the reconnoissance of the head-waters of the Missouri and the Yellowstone under Captain Raynolds, in 1859, 1860. The geographical results furnished by these various expeditions, and by many other less important ones, made under government auspices, have gone to the United States Engineer Bureau, and have been utilized in working over Warren's map of the United States. They were all reconnoissances, and almost without exception too defective in the astronomical determination of position to allow of their being used, except for a general map on a very small scale, where detail was not necessary, and where discrepancies of a few miles could be easily put out of sight.

Up to 1860, the United States had been entirely unsupported by the individual States and Territories in the work of adding to our stock of geographical knowledge of the Far West. The

Land Office Surveys — of which more presently — had made some progress in California and Oregon; but hardly a beginning elsewhere to the west of the Rocky Mountains. These two were, indeed, the only organized States west of the 104th meridian, and they together hardly contained half a million of inhabitants; but little was therefore to be expected from this quarter, unless done by the central government. At this time there was a good general knowledge of the geographical outlines of a large part of the region west of the Mississippi; only the southern and western portions of what is now the State of Nevada and a part of Utah were still marked on our maps "unknown." No detailed work, however, had been done in all this vast region, and the structure — both geographical and geological — of the mountain ranges was something which had not received the slightest attention. Even the elevations of the prominent mountains were unknown; not a single high peak, in all that vast complex of ranges which we call the Cordilleras, had ever been measured. There was also the chronic difficulty with regard to longitudes. Not a single point between the Mississippi and the Pacific coast had been accurately enough determined to justify its being used with confidence for subordinating other work to it. Salt Lake itself, which ought to have had the best established position in the region, since it had been made the special object of a costly expedition, was found by the telegraphic observations of the United States Coast Survey, in 1869, to be six miles east of the position which had been assigned to it by Warren.

In 1860, the State of California made a beginning in the direction of accurate work, by the establishment of a geological survey. Among the provisions of the Act, by which the work was authorized, was one requiring the preparation of "suitable maps," and this was construed by the State Geologist to mean maps as accurate as could be made with the means at his command. In the ten years during which this work was carried on, considerable progress was made in developing the detailed structure of both the Coast Ranges and the Sierra Nevada, and several maps were published, on scales of two and six miles; and also a general one of both California and Nevada, on the scale of eighteen miles to the inch. An

important work in four sheets, giving the topography of the whole Sierra Nevada, on the scale of 1 : 380,160, was nearly completed, and three sheets had been engraved in a style worthy of high praise, when the work was suddenly stopped by the Legislature in 1874, although the entire expenses of the survey in all departments, including geological and natural-history work as well as the costs of publication, had been considerably less than $20,000 per year from the beginning.

The explorations of the Central Pacific Railroad, for establishing their line, gave the first clear idea of the topography of the region between Salt Lake and the Sierra Nevada, along the thirty-ninth and fortieth parallels, — a region traversed by more than twenty nearly parallel ranges of mountains, many of which are little inferior in height and elevation to the Pyrenées. Several lines were surveyed through Nevada, in the hope that a feasible route might be found across these ranges, and that thus the road might be run direct to Salt Lake City, without the long detour to the north, by way of the valley of the Humboldt, by following which they would be obliged to leave what were then the most important mining districts of the Great Basin far to the south. By combining these surveys, which were executed by Butler Ives, a skilful topographer, a quite accurate map of the northern portion of the Great Basin was obtained; which, however, was never published. This map covered almost precisely the same ground as the western half of the Fortieth Parallel Survey, of which more presently. The Union Pacific Railroad made no surveys having any topographical value; but those of the South Pacific added some few items of importance to what was previously known of the region at the base of the Rocky Mountains in Colorado and New Mexico. The Northern Pacific, on the other hand, contented itself with compiling, from Warren's map and other authorities, a large and geographically worthless diagram, which was widely circulated, with the proposed route of the road indicated on it, and the sterile deserts of the Northwest as far north as latitude 52° marked in large capitals, "The Continental Wheat Garden!"

The "United States Fortieth Parallel Survey" and the

"United States Geographical and Geological Survey of the Territories" will be noticed further on, when we come to speak of work now in progress. At present, we have to turn our attention to what has been done in the States east of the Mississippi, and in the inhabited portions of the great valley of that river, towards working up the geography of the eastern half of our territory. And it may, in the first place, be stated, that for the valley of the Mississippi we have to depend chiefly on the United States Land Surveys, while for the Atlantic States the basis of our geographical knowledge is the United States Coast Survey, supplemented by a large amount of material of a very mixed nature, and not at all thorough in execution or trustworthy in detail. To appreciate the chartographic condition of this portion of the country, it will be necessary, first, to give some idea of the operations of our Coast Survey.

The United States Coast Survey is a work of such magnitude, so important to the geography of the country, and, withal, so creditable to American science, that it will be proper to take some pains to make ourselves acquainted, in a general way, with its methods and progress. It is the only great scientific work in this country which has been uninterruptedly carried on for any considerable time; and one of the few things done under the authority of the national government in which every American citizen can take pride. The importance of an accurate knowledge of the coast line of a commercial country like our own was something that the dullest and least scientific mind could hardly fail to perceive, and it is not surprising that such a survey was ordered; but it is, indeed, something to be wondered at, that a work, requiring such an amount of time and so large an expenditure of money, in order that it might be executed in a creditable manner, should have got itself fairly established as a national institution. Having been started, it was rather to be expected that it would be put in charge of some one who would contract to have it done within the shortest possible limit of time, and who would have had but one idea, — that of pocketing the largest amount of profit at the end of the operation. Indeed, it is rather a matter of luck than anything else that the Coast

inestimable importance to the scientific accomplishment of the survey." The item in question is, "for extending the triangulation of the Coast Survey, so as to form a geodetic connection between the Atlantic and Pacific coasts of the United States." The amount asked, which was granted by Congress, was only the almost insignificant one, as compared with the total demanded for the work, of $15,000; the whole amount called for to continue the survey being $746,000, while $643,000 was the sum actually voted by Congress for the previous fiscal year. In the Report of the succeeding year, 1871, we find that this estimate was increased to double the sum previously asked for, namely, to $30,000, and the proviso added, "that the triangulation shall determine points in each State in the Union which shall make requisite provision for its own geological surveys." In the same Report, information is given in regard to work done during the year in this department of the survey, and it is stated that a "few geographical positions had been determined in the vicinity of St. Louis, and others in the States of Ohio, Illinois, and Kentucky." Further on in the same Report, mention is made of the determination of geodetic points in New Hampshire, the triangulation being extended from the coast across the State, in the direction of Lake Champlain. A similar beginning was also made in the vicinity of St. Louis. For the year 1872–73, the amount appropriated by Congress for this interior geodetic work was $36,000, and the same for the next year; for 1874–75, and 1875–76, the appropriation has been increased to $50,000. What has been accomplished up to the present time, as we learn from the Superintendent of the Coast Survey, is as follows: *reconnoissances preliminary to triangulation*, from the Blue Ridge in Virginia to the Ohio River; through Southern Pennsylvania, and in the same latitude in Missouri; near Salt Lake, for a base-line site and for points to extend triangulation east and west of that site: *triangulation commenced*, east and west of St. Louis; from San Francisco, to cross the Sierra Nevada to the meridian of Austin, Nevada, and from Monte Diablo up the Sacramento Valley to Mount Shasta. Geodetic work or preliminary reconnoissances have been or are in progress in sixteen States.

The highest geodetic problem of the Coast Survey, that of

working up the observations with a view to contributing to our knowledge of the form and size of the earth, or, as it may be technically expressed, in the words of the superintendent, "finding the geometrical expression for a surface most nearly in accord with the results of astronomical and other observations, made in the progress of the primary triangulation," has received attention, we are informed; but nothing has as yet been published in regard to it. Whether it will be possible for the Coast Survey to keep up the high standard maintained under Bache's superintendence, remains to be seen. It is fervently to be desired that there shall be no falling off in the execution of a work to which we have been in the habit of looking for important scientific results, which we can hardly expect to get in any other way than through its agency.

The survey of the Lakes, carried on by authority and under the direction of the Department of War, the Coast Survey being attached to the Department of the Treasury, appears to have done its work well so far as the hydrography of our great interior bodies of fresh water are concerned. The work has, however, no great topographical importance, and it ought, for a variety of reasons, to have been executed by the Coast Survey, which, in extending its primary triangulation so as to form a geodetic connection between the Atlantic and the Pacific, might easily have crossed the continent in such a way as to embrace the region of the Great Lakes.

If we have in the Coast Survey a work of which we have some right to be proud, the system of the United States Land Office Surveys, on the other hand, is a very disagreeable subject to handle, since it is marked by the most serious defects, both of plan and execution. Little is known of these matters by the inhabitants of the older States; but in the West the terms "township," "range," and "section" are familiar as household words.

The United States is the owner (nominally at least) of an immense area of land, which has to be surveyed after some fashion before it can be sold or even given away. The Mexican government tried the experiment of giving away land, without defining its boundaries by survey, in California, before that region became United States territory, and the conse-

quence is, that many of the original grantees have been unable to maintain themselves against conflicting claimants, and have lost everything, while multitudes of lawyers have fattened on the spoils, and an amount of fraud has been perpetrated which fairly exceeds belief.

If one looks at an old map of our country, as it was before the Revolutionary War, it will be seen that the States are divided off from each other on the Atlantic shore and for a little way into the interior, but without any defined boundary to the west. Some States had, as they supposed, claims through to the Pacific Ocean; others extended indefinitely back into the wilderness, so far that the western part was beyond the reach of anybody: that was enough. When Cambridge was laid out, a route for a road was surveyed back into the wilderness for a distance of six miles; that was about as far, they calculated, as civilization would be likely to extend. Of course, when things were so indefinite, there must eventually be a good many conflicting claims. Connecticut, for instance, could not be extended to the Pacific without crossing over New York; so at length, after much discussion, the different States, responding to the appeals of the Revolutionary Congress, New York taking the lead, surrendered their claims to the general government. The United States held no land in any of the original thirteen States, except what was bought for public uses. Vermont was claimed by New Hampshire and New York, but was admitted to the Union as an independent State in 1791. Maine, previously claimed and governed by Massachusetts, was admitted in 1820. Kentucky and Tennessee also came into the Union without giving up any of their lands to the United States; but all the rest of our domain east of the Mississippi, forming the Republic as it existed in 1783, belonged to the general government, and comprehended altogether about 350,000 square miles. By additions since made, namely, by treaty with England, purchase from France, helping ourselves to valuable land belonging to Mexico, and paying her afterwards for worthless, our territory was multiplied sevenfold in area, making seventeen times as much as Prussia had before she commenced the last war, — and not including

our last doubtful purchase, Alaska. Not counting that trifling acquisition of 582,000 square miles, we have, or did have, of public land, 1,465,468,800 acres, as estimated, in 1866, at the General Land Office, much of it worthless, and yet including as fine a body of agricultural land as can be found in the world. Nearly all of Indiana, Ohio, and Illinois has already been sold or given away; and, of course, a large quantity in some of the other States has been disposed of, but a vast amount still remains on hand, although our public lands have been most lavishly given away by Congress, under every sort of pretext. For instance, in 1866, of 4,629,312 acres disposed of, only 388,294 were actually sold; the rest was all got rid of in some way which certainly did not bring any immediate returns of cash into the treasury. It is worth while, then, to learn how this vast body of land is cut up, and its subdivisions so marked that the purchaser may know where the tract to which he has acquired a title is located, — to use a convenient American word, which first came into use in connection with the public land surveys, and which meant originally the selecting of some part of the public domain for a home. It is only after a description of the Land Office system of surveys, that one can form an idea of the geographical value of the work. The area over which these surveys have been extended includes, of course, only land belonging to the United States, as designated above. In the Mississippi Valley and along the borders of the Great Lakes, from Western New York nearly to the western limits of Kansas and Nebraska, the country has almost all been surveyed, and offered for sale or given to railroad and other companies; but farther west there remains still a vast body of land into which the surveys have not been extended, partly for want of time, and partly because the land is not worth enough to make it reasonable to suppose that the amount expended on the work would ever be got back from its sale. Portions have therefore been selected, here and there, and brought into market as required; but there are no large bodies of surveyed land west of the Rocky Mountains, except in the Willamette and San Joaquin and Sacramento valleys.

The object of the United States land surveys is to cut the

land up into squares of one mile, which are called sections. This is done by means of the simplest and least accurate instruments, and such as require the least possible amount of skill for their use. The direction of the lines is given by the magnetic or surveyor's compass, and the distances measured with the chain. There is no triangulation or any similar accurate fixing of a net-work of connected points, by means of which the accumulation of errors is held in check; but the general idea of the methods followed can be given in a few words. If we suppose a line accurately run from south towards the north, or in the opposite direction, all points on that line will have the same longitude. Such a line is run, theoretically, as the beginning of the survey of a certain district, which may embrace a part of a State, or portions of several adjacent ones. The line thus run is called a principal or guide meridian. At right angles to this another line is traced, and called the base line. From the two lines thus established other lines are run and measured with compass and chain, by which the ground is divided off into squares of six miles, called "townships," and these again into subdivisions of one mile square, called "sections," a section containing, "as near as may be," 640 acres. In the centre of each section line a post is set when the line is run, and this is called a "quarter-post," because it answers the purpose of indicating a division of the section into quarters of 160 acres each. By an ingenious system of notation, it is so contrived that any section of land may be easily designated by reference to the number of the meridian to which it belongs, and to its position east or west of that meridian and north or south of the base line. That this system is one very convenient for temporary use, in bringing the public lands into market with the greatest expedition and at the least possible cost, is not to be denied; but what will be the future consequences of the adopting of a method so inaccurate remains to be seen. We have only, at present, to busy ourselves with the geographical material furnished by these surveys. In the first place, the entire unavailability of the system for mountainous regions is to be noticed. The lines cannot be run with a compass and measured with a chain with even a rude approach to accuracy, except in a region

which is, at least, moderately level. This is shown by the fact that the townships and sections, in the few cases where the work has been carried into the mountains, have proved, on examination, to be extremely irregular in shape; and it is a fact, that the surveys have been mainly confined to the level strips of land between the ranges, throughout the whole of the mountainous western portion of the country. The system which answered tolerably for the flat or gently undulating plains of the Mississippi Valley, has been found quite unavailable for the Cordilleras. And, as no topography or hill-shading is given on the plotted sheets of these surveys, no idea of the physical structure of the regions they embrace can be obtained from them, or any map constructed by putting them together, except where the country is destitute of mountain ranges. Of course, as the lines are only run so as to divide the surface into squares of one mile each, all within those squares is a blank, except in so far as it may be deemed reasonable to fill them up by arbitrarily connecting the objects intersected on their borders.

In point of fact, the system of the Land Office Surveys is not only unsatisfactory in itself, but the work has been, much of it, very badly executed. We do not allude here to the defective and even fraudulent character of portions of the less important details, but to those prominent features, the principal meridians, by which the rest of the work is co-ordinated, and which have first to be laid down on the map, whenever Land Office material is to be used for geographical purposes. And it will, we think, excite some surprise after reading in a report of the Commissioner of the General Land Office, the head of this department of the government business, that the guide meridians and standard parallels are "run, *as nearly as human skill can effect it*, upon true meridians and parallels of latitude," * to learn that, in truth, portions of these lines are miles away from where they ought to be, in order that the above statement in regard to the accuracy of the work should be true.† In order

* See Report of the Commissioner of the General Land Office for 1866, Part I. page 8.

† Those who desire to investigate this matter will find it discussed in a chapter of Foster and Whitney's Lake Superior Report, Part II., written by Charles Whittlesey, and also in Warren's Memoir, referred to above.

that the Land Office work may be utilized at all on any map of the United States which can lay claim to be accurate, the longitudes of all the principal meridians will have to be carefully determined at various points along their course by means of the telegraph. This could be easily done, for the meridians in the valley of the Mississippi, which pass, in good part at least, through a thickly inhabited region, intersected by railroads and telegraphs, and of all the geographical work needed at the present time in the country this is the most important. And should the Coast Survey succeed in extending its triangulation across the country, its officers ought to be required to connect their work with the Land Office Surveys, and to establish permanent monuments at suitable points, which should be most carefully protected by legislation, if it be possible in this country to bring about so desirable a result.*

When we come to inquire on what besides the Coast Survey we have depended for the chartography of the eastern Atlantic border, that is, what material has been used in the construction of the maps in common use of the various States from Maine to Georgia, the question is a difficult one to answer; and it becomes a still more perplexing task when we seek to learn what is the relative or absolute value of the material thus used. Chain and compass surveys, either of the towns, the counties, or the States, made for the purpose of fixing their respective boundaries, constitute the principal body of this material; and it has been so long accumulating, that it would be a most tedious and unsatisfactory matter to search out the history of these fragmentary undertakings. Indeed, this could only be done under the authority of the various States, and with diligent investigation of their archives. Discrepancies of several miles are believed, with good reason, to exist in the boundaries of some of the States; and the recent re-examination of the line between two of them —

* There is something truly alarming in the thought that the lines of the United States Land Office Surveys can never be run over again, or their location be re-established, after the marks by which the work is indicated on the surface have been obliterated. And these marks are only small wooden posts, mounds of earth, or "blazes" on trees, none of which can survive many years, while most of them disappear very quickly, unless some one has a special motive for their preservation.

New York and New Jersey — has shown very clearly how full of errors the old compass surveys were, even when best done. The only States which have undertaken any systematic surveys, for the purpose of securing correct maps of their territory, are New Jersey, Pennsylvania, and Massachusetts, and in no one of these instances has the result been satisfactory. New Jersey made a very creditable beginning, having an excellent basis in the Coast Survey triangulation, which, from the peculiar form of this State, extends over no small portion of its area. The work, begun in 1854, was carried on for two or three years and then suspended, although a good deal of valuable material was collected which was afterwards utilized in the State geological map. A large amount of topographical work was done in Pennsylvania, in connection with the State Geological Survey, in the way of improving the map of that State; but there was no accurate triangulation made, neither was the topographical map which was constructed ever laid before the public, although it was used to some extent in the geological atlas accompanying the final report by H. D. Rogers.

Massachusetts was, however, the first to institute what was intended as a topographical survey, but which really turned out to be only a triangulation, bearing the same relation to a finished survey that a skeleton does to the living body. It will be worth while to look a little more closely into this matter, and to set forth the errors into which the Legislature fell from entire ignorance of the subject. This ignorance was, perhaps, not so blameworthy forty-five years ago, but it would be inexcusable for the State to enter on another work of this kind, without more knowledge of what is needed, and of how such a survey should be executed, than existed in this community when the former survey was instituted.*

In 1829 a committee was appointed by the Legislature of Massachusetts to take into consideration the subject of "procuring such a map or such maps of the Commonwealth as the public good requires"; and in the following year this com-

* Yet at the very time the Massachusetts Survey was going on, Bessel and Baeyer were doing the most exquisitely accurate geodetic work in Prussia, not to speak of the Ordnance Surveys of England, France, and other European countries.

mittee reported that "a good map, projected on a large scale, from actual surveys," was much needed. The old map of the State, made in 1801, "from authentic sources," and the surveys for which had been ordered by the Legislature in 1794, was no longer sufficient. The idea of a topographical survey and map seems to have been rather mixed up in the minds of this committee with that of a census and gazetteer; for in their report they state that, as a new census of the United States has to be made in 1830, as well as a new valuation of the States, "a great mass of appropriate information could be obtained free of expense." The committee did, however, see the necessity of a survey "on trigonometrical principles," and they thought that the work could be done "by some scientific gentleman," in one season, with such assistance as would be derived from information already on hand. If such a survey could be made, another one would never be needed; but it is modestly added that "a small appropriation for this purpose would be required." The idea was, that each town should make its own chain and compass survey. "Such a survey could be made by the selectmen," as the report has it, and the material thus acquired was to be put together on trigonometrical principles by the "scientific gentleman" employed to superintend the work. The engraving and printing, it was thought, could be paid for from the proceeds of the sale of the map. The action of the Legislature was in accordance with the above-cited recommendations of the committee; an appropriation of $2,000 was made to carry on the work, and the towns and cities of the Commonwealth were required, under a penalty for non-compliance of $100, to have minute and accurate surveys of their respective territories made within a year, and the State surveyor was to "project an accurate skeleton plan of the State," which should "exhibit the external lines thereof, and the most prominent objects within those lines, and their locations."

The triangulation was mainly executed by Mr. Simeon Borden and completed in 1839, with a higher degree of accuracy than was to have been expected under the circumstances, and in a manner very creditable to Mr. Borden's ability and perseverance. The astronomical portion of the survey was under

the direction of Mr. R. T. Paine, and small portable instruments were employed, namely, the sextant, or reflecting circle,* and a number of chronometers. The precise object for which these astronomical observations were made, it is not easy to understand, as it is not likely that they were ever used in rectifying the triangulation, which was of a higher order of accuracy than the astronomical work. When, however, the chain and compass surveys, made by the selectmen or their agents, came to be fitted into the main triangulation, — which should have been supplemented by a secondary series of triangles, so as to largely increase the number of points established, — there was much trouble, as might have been expected. It was an attempt to reconcile data of a very uncertain character; indeed it was a most thankless job, and the result was not satisfactory, falling far behind what had been expected, although the work had occupied thirteen or fourteen years, instead of the one year it was expected to take when commenced. The map as finished was on too small a scale — two and a half miles to the inch — to be of much use as a town or county map, and of course of no service as marking the lines or divisions between the estates of private parties. It was also very defective in respect to its exhibition of the character and relief of the surface, this being an item in the requisites of a good map not at all appreciated in this country at that time. A new edition was issued some years afterwards, on which an attempt was made to improve the hill-shading, which, however, was still very unsatisfactory.

Maps of several of the counties and towns of Massachusetts and New York, and probably of some other States, have from time to time been prepared and issued by private parties, who appear to have found the business profitable. The surveys for the county work appear to have been made by driving over the roads with an odometer attached to a wheel of the vehicle used, thus determining the distances with some approach to accuracy, while the pocket compass was probably chiefly relied on for direction. The names of the occupants of the houses are

* The name of the instrument is not given in Mr. Paine's report of his operations; it is simply called "a reflecting instrument."

given, and small plans of the principal towns figure on the borders of these maps. Chartographic work of this kind is very defective, especially in the way of hill-shading; but it is better than nothing at all; and the fact that such maps can be made and sold with profit indicates very clearly how strongly the want of good ones is felt by the people. The books of city maps furnished by private enterprise are more satisfactory than the county maps, but still far from being complete, and they especially lack the stamp of "official" upon them, so that they cannot be used where permanency and the law are to be taken into consideration.

From what has been said above, it will be readily gathered that we have very poor local maps of the Eastern States, and no good general one. One would suppose that the grand chain of the Appalachians, situated as it is in the midst of a civilized nation, would be well known to us even in the details of its remarkable and beautiful physical structure. This, however, is not the case; and if it is no longer true, as Guyot said in 1861, that it is "one of the chains of which we have the least amount of positive knowledge," it is chiefly due to the persevering and unremunerated labors of that distinguished geographer, during a decade of years, that we have now even a general idea of the character of this chain. Professor Guyot's investigations have had reference rather to the previously entirely unknown altitudes of different portions of the Appalachian range than to its structure; what we know of the latter is more to be gathered from his published verbal descriptions than from the accompanying map, which is on so very small a scale (1: 6,000,000) as to be, in fact, only a sketch.

Professor Lesley, who was the principal topographical assistant on the first geological survey of Pennsylvania, has also interested himself much in regard to the structure of the Appalachians, and even prepared a large map intended to illustrate the peculiar features of different portions of the range; this was, however, never published, although a part of it was photolithographed, as an illustration of a paper in which the typical topographic forms of this remarkable chain were discussed.

The deficiency of our knowledge of Appalachian topography may be, in part, excused, it is true, by the difficulty of survey-

ing an intricate region of ridges of nearly uniform elevation, and densely covered with forests, which impede the vision, and thus render it impossible to work with rapidity; but the real trouble is, that the people have not yet been educated up to the point of fully appreciating the scientific interest as well as the practical value of accurate geographical and topographical work.

Mention should be made of the fact, that, during the War of the Rebellion, a considerable amount of topographical material was obtained, through the assistance of the Coast Survey chiefly, in parts of Tennessee, Kentucky, Virginia, and other States which were then the seat of war. The need of the kind of information which only an accurate and detailed survey can give was keenly felt at the time our armies were moving over the *terra incognita* of the western slopes of the Appalachians, and it was hoped that the impetus given to this kind of work at that time would continue to be felt after the war was ended, and that the result would be, that under the lead of the older and richer States, the work of mapping the Atlantic border of the continent would be seriously taken in hand. Nothing has been done, however, and we remain apparently very much in the same condition as to geographical progress that we were in ten years ago. This is the case, at least, with regard to action on the part of individual States; but the United States has taken several steps in advance, some of them very curious ones, as will be seen further on.

The United States Engineer Bureau has received from Congress large sums of money for many years back, nominally for "surveys for military defences." A considerable portion of this has been used for the topographical reconnoissances referred to on previous pages, and for many other similar and less important ones. The total amount thus expended it would be quite impossible for one outside of the bureau to state; but it must have been very large, probably not less than $100,000 a year, on the average. Previous to 1867 no system of surveys had been inaugurated, and but little if any work done of a permanently valuable character. The determinations of distances were almost exclusively dependent on estimates of the pace of the horse or mule ridden, and the

astronomical observations by which the work was checked were extremely unreliable. This is well illustrated by reference to Lieutenant Simpson's work in the Great Basin. His longitude of Genoa, one of his three principal astronomical stations, where a series of observations of lunar culminations was made, appears now from the telegraphic determination of the position of the 120th meridian by the Coast Survey, to have been over eight miles out of the way. And in further illustration of this, it may be stated, that on comparison and reduction to one scale of all the work done in the Great Basin by the United States Engineer officers, previous to 1867, by the writer of this article, it was found that no portion of it could be used for a general map of Nevada even on a small scale; indeed, the discrepancies of longitude and vagueness of the topography were so great on all the published maps of the War Department and Engineer Bureau, that no one chain of mountains, between the Sierra Nevada and the Wahsatch, could be identified as being the same with any range on the carefully surveyed map of Butler Ives, spoken of above, and which proved, on repetition of the work by the Fortieth Parallel Survey, to be remarkably accurate in its general delineations of the mountain masses, although in part deficient in detail.

In 1867 the Fortieth Parallel Survey was instituted by Congress, and the work placed nominally under the direction of the Bureau of Engineers, but in reality given to a civilian, Mr. Clarence King, who had as his principal topographical assistant Mr. J. T. Gardner, both of these gentlemen having been previously connected with the Geological Survey of California. Under Mr. King's direction, a belt of country over a hundred miles wide and extending from the western borders of Nevada to the eastern base of the Rocky Mountains was topographically and geologically surveyed with a much higher degree of precision than had ever before been attained in that region. The whole area was carefully triangulated, and the work checked by accurate telegraphic determinations of longitude at suitable points, as well as frequent observations for latitude with the zenith telescope. For the geographical map, which is comprised in ten sheets, on a scale of four miles to an inch, the hill-shading has been carefully and beautifully ex-

ecuted with the brush, and copied in crayon-work on stone. The geological work will be exhibited on contoured sheets, the curves being drawn at vertical distances of four hundred feet. Thus picturesque effect is combined with accurate delineation of the vertical element, so far as is practicable on the small scale necessarily adopted in the survey of so vast a region. This work is nearly ready for publication.

The success of the Fortieth Parallel Survey and the generally recognized value of the work led the Department of the Interior to inquire whether they also could not do something in the way of more accurate topography on the western side of the continent. A geological survey had been going on for some time, in the Territories of the United States, and under control of the Secretary of the Interior, but having no connection with the General Land Office, which is another branch of that department. This geological work, having no geographical basis, was of little value, except as a rough preliminary reconnoissance. To remedy this difficulty, it was proposed, in 1870, that a topographical corps be added to the geological, and, the sanction of Congress having been obtained, this was done. The remodelled survey was then known as the "United States Geological and Geographical Survey of the Territories," and the topographical portion of the work was placed in charge of Mr. Gardner, the principal triangulation of the Fortieth Parallel Survey having at that time just been completed. For the continuation of this work Congress has made liberal appropriations at the two last sessions, $95,000 having been granted for the present year. The work thus far has been mainly confined to Colorado, and a map of that recently admitted State, in six sheets, is said to be in preparation. It is in the area which lies between the meridians of 104° and 110° and is included between the parallels of 36° and 39°, that the survey is to be prosecuted during the season of 1875. This embraces Southern and Southwestern Colorado and the northern part of New Mexico. Of the scale or style adopted for publication in this work no information has been received. A preliminary sketch showing the progress of the triangulation in Central Colorado, on a scale of eight miles to the inch, is appended to the report of progress for 1873; and a description of the

method adopted for measuring the base line, and of the system pursued in the triangulation, is also added. From what has been published it may be inferred that this work will not fall short of that of the Fortieth Parallel Survey in accuracy, and that it will be of a much higher grade than any of the previous reconnoissance maps of the United States Engineer Bureau, in the region west of the Rocky Mountains.

Mention should here be made of a survey of the Colorado River, which has been going on for about five years, first under the direction of the Secretary of the Interior, and afterwards under that of the Smithsonian Institution. This survey, which is in charge of a civilian, Mr. Powell, had cost, up to the end of June, 1874, about $62,000, and a liberal appropriation was made in addition by the last Congress for its completion. From Mr. Powell's statement, submitted last year to a committee of Congress, it appears that an area of 45,000 square miles of territory about the head and along the course of the Colorado River had been explored and surveyed by his party. This region is an exceedingly difficult one to map, being much cut up with deep gorges and cañons, and very dry, as well as distant from any practicable base of supplies. It is understood that this survey has been in part based upon a triangulation; but nothing has been published as yet from which any opinion can be had with reference to the style and accuracy of the work. It was probably admiration of Mr. Powell's pluck and endurance, as manifested in his at first almost unaided exploration of the cañon of the Colorado, which led Congress to encourage and adopt the work, rather than a knowledge of his having had any scientific training or peculiar fitness to be at the head of a topographical or geological survey.

The two surveys just spoken of, as will be evident, are duplicates of each other, since to a certain extent there does not appear to be any limit fixed to either of them by Congress so that they shall be prevented from overlapping. The term "survey of the Territories" is, of course, an unmeaning one, since that which was a Territory to day may be a State tomorrow. Thus Colorado, in which most of the topographical work under Mr. Gardner's direction has thus far been done, is now within the Union, although only a Territory when the

survey was begun. A survey of the Colorado River might, on the other hand, without any impropriety, be made to cover all or nearly all of Arizona, Colorado, Utah, and Wyoming, since all these are largely drained by the Colorado and its tributaries. Thus we have two independent geological and geographical surveys over an area of not much less than a quarter of a million of square miles west of the crest of the Rocky Mountains, and it will be noticed that these are both under the control of the Secretary of the Interior, one of them directly and the other indirectly, yet both supported by special grants from Congress. This may appear to be a singular arrangement; but the reader will be surprised to learn that a third geological and geographical survey of the same area is also in progress, under the direction of the Engineer Bureau of the Department of War. This work is usually known as "Wheeler's Survey," having been in charge of a United States engineer officer of that name. It was begun in 1869, and last year the first number of an atlas was issued which gives an idea of the general plan and execution of the work.

According to an outline sketch in the atlas, the whole region west of the one hundredth meridian is to be represented on ninety-four sheets, each eighteen by fifteen inches in size, and on a scale of eight miles to an inch (1 : 506,880); of these four are given in the first number, and these cover very much the same ground which is intended to be embraced in Mr. Powell's map. Thus far the field-work of Wheeler's Survey has been almost exclusively carried on in the same region in which Messrs. Powell and Gardner have been employed, and it is evident that this has not been done without design. It has been, and probably still is, the wish of the Engineer Bureau to put a stop to all topographical work done in the region west of the one hundredth meridian, except such as may be under their own direction. It has been for the purpose of forcing this issue, that the region in question has been divided off as mentioned, and that particular region selected for exploration which others were already engaged in mapping. Indeed, the matter has already been up before a committee of Congress, and a very unpleasant altercation had between the officers and employees of the War Department on one side and of the In-

terior on the other.* Those who wish to investigate the subject can find material for doing so in the documents to which reference is made in the foot-note. In point of fact, no good has been accomplished by the Congressional investigation; the work is still going on exactly as before. Instead of a careful and systematic consolidation of all the United States geographical and geological work in the Far West, under one supervision, in one department, there is just that method employed which leads to bad results and great waste of money. Congress is at this moment paying to have the same work done, on the same ground, by two, if not three, different parties, and in two different departments. At the investigation referred to above, the influence of the most eminent scientific men throughout the country was exerted in favor of the continuance of the geographical surveys begun by Mr. Gardner under the direction of the Secretary of the Interior. This was done because, as was clearly shown before the committee, the four maps issued by the Engineer Bureau, as a first instalment of the "Geographical Explorations and Surveys West of the One-hundredth Meridian" were so defective and so far inferior to the work of the "Fortieth Parallel Survey," that it seemed inconceivable that, when the public attention was called to the fact, the poorer work should not be stopped and the better allowed to proceed. Instead of this, liberal appropriations were made for both classes by Congress, this year as well as the last, and how long this condition of things will be allowed to continue no one can foresee. To those who, like the writer of this article, earnestly desire to see the geography and geology of the Far West carefully and economically worked out, and who know what a tedious and costly job it must be, even when most economically and conscientiously carried on, the present state of things is indeed disheartening. It shows, perhaps as well as anything can, the defects of our system of managing public affairs, if system that can be called which has no other basis than the whim of a Congressional committee, or the tact and persistency of some individual who has a private object to gain, and who for this purpose seeks a position for which he is neither fitted by education nor by natural gifts.

* See House Report, No. 612, 43d Congress, first session; also Senate Report, No. 311, same session, and House Executive Document, No. 240.

It is something for which to be thankful that the opposition of the Engineer Bureau has not succeeded in wiping out the appropriations made for the extension of the Coast Survey triangulation through the interior. And yet the amount given for this purpose, thus far, is hardly more than a nominal one. Even if the whole sum were confined in its expenditure to a single State, it would not be more than enough to push the main triangulation in that one with even a moderate degree of rapidity. This may easily be inferred from the fact that, although the Coast Survey has been going on for about twenty-five years on the Pacific side of the continent, the main triangulation along the coast line, forming the basis of the hydrography, is very far from being finished; one would say from a glance at the progress-sketch published in the Report for 1870, that it was not by any means half done, and this, of course, without including Alaska. Yet the amount appropriated for the work on that coast seems to have been quite large, since it was, for the year 1870–71, $200,000, while $275,000 was asked for its continuance in 1871–72.

We have thus reviewed the sources of chartographic information in the United States at the present time, and endeavored to show, to the best of our ability within the limited space available, what has been done and what is now doing in the way of gathering the materials for the complete elucidation of the geography of this vast country. We have next to turn our attention to surveys which are designated as "geological," and to show what their object is, and what progress they have made in different parts of the world, and especially within our own borders. We shall then be prepared to discuss, somewhat more in detail than has yet been done, the character of the topographical and geological work needed by that one of the United States which is most densely populated and wealthiest in proportion to its area. In doing this we shall have occasion to examine and criticise the official report presented to the Legislature in November last by the committee appointed "to inquire into the expediency of a new survey of Massachusetts."

II. GEOLOGICAL.

In a previous article we have discussed the subject of Geographical Surveys, and now turn to those which are known by the term "Geological." Our object, at present, is, to explain why geological surveys have been instituted in different parts of the world, and by all, or nearly all, civilized states; then to show, in a general way, what has been accomplished by them in other countries, and also, and more particularly, in our own. We shall then be prepared to consider what is needed, in a State like Massachusetts, in the way of geographical and geological work, in order that the public interests may be best cared for, and the claim which our people generally make, that they have a right to take a high rank among civilized communities, be justified, in that which concerns a thorough knowledge of their territory and the development of its resources.

And, to arrive at a satisfactory result, it will be desirable, in the first place, not so much to explain what geology is, as to show what the economical bearings of the science are, and how it connects itself with the material welfare and progress of the State; and, with this object in view, the relations of different governments to the mining interest will be set forth, although necessarily in a very concise way, since a full development of the subject, demanding not less than a whole volume, would be quite out of place here. That geological surveys are in some way expected to be of great value to the community is evident from the fact that they have been extended over so large a portion of the most enlightened countries; and that important results have been attained may also be taken for granted, because these surveys are constantly gaining in extent and in the scope and magnitude of the work undertaken. And yet, in this country at least, it is very doubtful whether more than a small number of the people really have any just appreciation of the nature of the operations of a thorough geological survey, while it is certain that there are but few persons who have sufficient knowledge of the subject and confidence in the value of the work done to be able to use it as it

ought to be used, in order that a full return for the outlay incurred may be obtained.

All know, more or less definitely, something of what the science of geology is; and that while the geographer has to do with the surface of the earth, the geologist has not only to look at the surface, but also to endeavor to ascertain what is beneath it. Geography is one of the plainest and most straightforward of sciences. The mapping of the earth's surface, or the exhibiting on paper of its physical features, and the delineation of its artificial subdivisions, are tasks of great ease and simplicity. Work it is, to be sure, which demands time and patience, and which requires the expenditure of a great deal of money, where accuracy is desired: but there is nothing of theory or hypothesis about it. When, however, we enter the domain of physical geography, or that more general form of the subject which has for its object the investigation of the laws governing the system of physical movements which take place upon the surface of the earth, we find ourselves in presence of a much more difficult task. The majestic sweep of the oceanic currents, the disturbances of the atmospheric equilibrium, the theory of the tides, — these and kindred subjects demand, not only prolonged and accurate observations, but the aid of the highest mathematical analysis; and we may feel assured that many years will elapse before all the problems presented to the investigator in this department will be solved. It is where physical geography ends that geology begins; and, as we go backward in time and endeavor to ascertain how the great dynamic agencies now moulding the earth's surface worked in the earlier epochs of its existence, we follow a road which is continually becoming blinder and more difficult.

Indeed, it has been, and often is, made a matter of reproach to geologists that their science is one in which hypotheses and theories predominate over facts; and it is especially urged against it, that it does not furnish numerical results — that its fancies are many and its figures few. This is, indeed, true, and yet geology has done more than any other science to correct the former erroneous ideas of men in regard to the length of time during which the earth itself, and man upon its sur-

face, have been in existence. The results of geological investigation, although not capable of being put into figures, are as grand as any with which astronomy has furnished us; and that which the latter science has done to enlarge our conceptions of the extent of space cannot be considered as having had any more powerful influence on the intellectual development of mankind than have the revelations of geology in regard to the immensity of time required to allow for the occurrence of that complicated series of changes which the study of the earth's surface, and such of its interior as is accessible to us, has shown to have taken place. It is true that the temptation to theorize and speculate, on a basis of small knowledge, may justly be charged against many who would consider that their claims to be called workers in geological science are beyond dispute. It is true also that for centuries geology consisted of little or nothing except speculations, many of which were wild and fanciful; but the last half-century has seen an immense change in this respect. Following the lead of the Geological Society of London, the really earnest workers in this line of research have accumulated a body of facts which it is already extremely difficult for any one man to handle. The Transactions and Proceedings of the various important societies exclusively devoted to geology form a library of no insignificant size; and the reports of the various official and government surveys fill a goodly length of shelving in one's library. Indeed, if geology has its imaginative and poetic side, it has another one of quite the opposite character. Let one examine, for instance, the bulky royal-octavo volume of the English Geological Survey, devoted chiefly to the details of sections of wells about London, and he will find that figures do there most abound. What can be more matter-of-fact than a sheet of coal-mine sections, in which, in a series of hundreds of alternations of beds of shales, grits, and coal, the thickness of each particular stratum is given with accuracy, as well as the minutest details of the peculiarities of its lithological structure! And these data, which are not obtained without much labor, but which look so unattractive to those not specially interested, may be of the greatest importance to persons mining or owning property in

the region where the sections in question have been prepared; and they may be studied with the closest attention, and with results bearing directly on the welfare of the people, when placed in the proper hands.

The difference between geology and astronomy may be illustrated by comparison between the study of the phenomena of an eclipse and an earthquake, both of them events which in ancient times struck terror into the hearts of the multitude; although in the case of the eclipse the feeling could have been one of unreasoning apprehension only, while the earthquake was known to have been often highly destructive in its effects, and therefore with reason to be dreaded. Now, the exact time of the occurrence of the next eclipse can be given with precision, because it depends on one simple law, always the same in its action, so that the motions and positions of the heavenly bodies can be ascertained by the aid of mathematical analysis for any future, as well as for any past epoch. The phenomena of the earthquake, on the other hand, depend on several causes which are not regularly recurrent in their action, and which in their mutual play acquire a degree of complexity which puts it quite out of our power to say at what particular epoch the tension of the crust will have reached such an amount, at any particular spot, that a seismic disturbance or earthquake will take place. After the shock has occurred, a great deal of important information can sometimes, if the conditions are favorable, be obtained as to the depth at which the shock originated, the way in which the vibration was propagated, and the manner in which its effects were made evident upon the surface. Looking at the matter from a general point of view, it can be shown what regions are most liable to severe disturbances, and the architect and engineer can be cautioned as to the necessity of planning their constructions so as to offer the greatest amount of resistance to the devastating agency. Thus interesting and important scientific as well as practical results are obtained, a portion of which are given approximately in figures; while by means of the combination of a great number of observations — which may perhaps have to be continued for centuries — we may at length arrive, not to that point where we shall be able to predict the time of the occur-

rence of earthquakes (which would, from some points of view, be a misfortune), but rather to a complete understanding of the causes of these terrible catastrophes, and of the best methods of providing against their effects.

It is chiefly through its intimate connection with the art of mining and the development of the mineral resources of the country, that geology has acquired the importance which it now has, and especially in its relation to the state. But little has ever been done by any government to encourage scientific research where there was not some pretty direct practical result to be attained. It is only within the most recent times that the fostering of investigations made for the purpose of extending the boundaries of science, and not with an eye to any immediate practical application, has begun to be recognized as a duty. It is true, however, that in some branches of science — notably in astronomy — governments have been led to do a great deal for abstract science and to pay liberally for work which could, at present at least, only be seen to be very remotely connected with the material progress of the people. But this has only been by fits and starts, just as the right string in the popular mind happened to have been struck, or when the sentiment of international rivalry had been called into play. Thus England, after many years of the most profound indifference to Arctic discovery, suddenly awoke to the idea that this line of inquiry was of the greatest importance: the brilliancy of the achievements of the Germans and the Americans could not but be admitted, and must be surpassed. Thus, too, in the observations of the recent transit of Venus, where it would be difficult to demonstrate that the results would have any other than an exceedingly remote practical value, all the European nations vied with each other as to which should send forth the most thoroughly equipped band of observers. It was generally admitted everywhere that this was the proper thing to do. But when Gilliss went to South America and established an observatory for the purpose of determining the distance of the sun by observations on Mars, hardly an observatory could be found in the world willing to go a little out of its regular routine for the purpose of making the necessary corresponding observations; and not a government lifted

its finger in help, even when the expense incurred would have been absolutely insignificant, as compared with that of the late Venus expeditions. Again, that the patronage bestowed by governments on scientific research is fitful in the extreme may be illustrated by the indifference of the Ministry and the people in England to the deep boring now going on for the purpose of settling some points in geology bearing, not so very remotely, on questions of the highest commercial importance to the country. There is, in this case, not that immediate brilliant result to be attained which happens to fall in with the dominant fancies of the people; in short, that kind of thing is not exactly in fashion at the present moment.

In the matter of the encouragement of science through the means of geological surveys the governments of Europe have, almost without exception, shown themselves far-sighted and liberal in their expenditures; but it is the practical which has been aimed at, and the scientific results have been had, into the bargain, without having been at all looked forward to as a part of the *quid pro quo*. Indeed, the way in which geological surveys have come into being in Europe is something not at all a simple matter as it is with us; but they have resulted, in most cases more or less indirectly, from the connection of the governments with the mining interests, — a connection which dates back to before the time when geological science had any existence.

If the phenomena of coal deposits, as well as of iron to some extent, are comparatively very simple and only require care and accuracy for their setting forth, so that capital may have a solid basis of fact on which to rest, this is far from being the case with most of the occurrences of the metalliferous ores. Metal mining is proverbially uncertain, and in proportion as it is uncertain, so it is attractive. Nature has stored away in the bowels of the earth many great prizes and a prodigious number of blanks; and human nature is such that there are few things about which it is accustomed to get more excited than in regard to occurrences of metalliferous indications, especially those of the metals styled precious. No one who has not had practical experience of these matters can realize how much energy and time have been used up in foolish mining enter-

prises, especially on the western side of our continent, and how much fraud and rascality have been mixed up with the development of our metallic wealth. It is safe to say that, for years, half the resources of the State of California were wasted in profitless and foolish "prospecting," or preliminary attempts at mining; and it is a well-known fact that several times in its earlier history that State was completely demoralized by the "rush" * — thus wild and senseless migrations of bodies of miners from one mining region to another are termed — of a large portion of its male population to some new El Dorado, where many of them left their starved bodies, while the rest came back in poverty and rags.

It is partly owing to this peculiar tendency of men to wasteful and heedless squandering of time and money where mining matters are concerned, that the civilized European governments have, from time immemorial, taken this department of industry under their special charge. But there is another important element to be taken into consideration in this connection: this is, the sovereign right of the state to the metallic treasures buried beneath the surface.

At the present time, the object of governments in interfering with mining matters is chiefly to prevent foolish and extravagant expenditures and a wasting of the resources of the country; the idea of the divine right of the sovereign to the metals — precious or base — found beneath the surface has, to all intents and purposes, been abandoned by the enlightened states of Europe. But this has not been brought about without hundreds of years of struggles and contest, in which popes, emperors, princes, and the people have all played their parts. In this country no such complications have ever arisen. The individual States have never attempted to exercise any sovereign right over the treasures buried beneath the surface as distinct from the soil itself. The general government, as the actual owner of the soil over a large part of the country, as already shown, has had full control of all that exists upon or beneath it; and whenever Congress has done anything in refer-

* See "Mining in the Pacific States of North America," by J. S Hittell, San Francisco, 1861, p. 29, *et seq.*, for a description of the Frazer River "rush" in 1858, as a specimen.

ence to the sale of the mineral lands of the country, it has been because the United States was the exclusive owner of the ground, and not because there was any question of exercising the rights formerly claimed by sovereigns over the minerals and ores discovered within their territories. To undertake to show how and by what complicated series of steps the different states of Europe have been brought to their present stand-point in regard to mining matters would occupy far too much space in this connection. It need only be stated, in a few words, that it has been brought about because governments have become more enlightened, and because sounder ideas of political economy are now prevailing. It is seen to be for the best interest of the state that mining should be as little hampered as possible; that people who are willing to risk their capital in this way should be encouraged under wise restrictions to go on; that the owners of the soil should not have it in their power to obstruct others who are willing to incur the risks which they themselves decline. And yet it is fully recognized that men must be guided by the light of science in their expenditures, and be restrained, as far as possible, from wasting their own money, and more especially from wantonly destroying the wealth existing beneath the surface. For every mineral deposit is of limited extent, and it is the state's interest that no more than is necessary should be lost in the working. A mine may be so unskilfully handled as to make it necessary that it should be abandoned long before it is exhausted, thus, to all intents and purposes, annihilating, so far as the public use is concerned, a portion of its contents; or the ores taken from it may be wastefully treated in the processes of dressing and smelting which they have to undergo in order to obtain the metal from them. Here is a source of immense waste, against which it is the duty of the state to guard. For the metallic wealth included within the bosom of old mother Earth is not like the riches which her surface so bountifully provides. Forests will in time spring up again to replace those which have been recklessly removed; exhausted soils may be made to recover their fertility; but the contents of a mineral vein or deposit are there once for all, and if wasted in their removal the loss can never be repaired.

To understand something of the present position of the prin-

cipal European states with reference to mining and geological work, it will be well to examine into what France, Germany, and England are doing in the way of encouraging and protecting the development of their mineral resources, by wise laws regulating the working of mines, facilities afforded for the highest instruction in this department, and minutely accurate surveys of their territories. And we may begin with France, a country where there are few important mineral deposits, except those of coal and iron; while these are usually of such a character as to make their working difficult and expensive, so that the help of scientific control has been of great value, partly in checking foolish expenditures, and partly by directing work in progress, so that the best results might be attained, and the element of uncertainty eliminated, so far as this was possible.

In France, the Corps des Mines was established in 1781; and, about the same time, the École des Mines. This mining school was first an elementary one; it afterwards underwent several modifications, and finally became an institution into which a small number of the graduates of the École Polytechnique and those standing highest could be admitted as "élèves ingénieurs," and a few more as "élèves externes," on passing the necessary examinations. The "élèves ingénieurs" are, to all intents and purposes, government officers; but they can only be promoted to the rank of "ingénieur des mines," and be charged with the duties of that position, after passing through the course of the École des Mines.

The Polytechnic School is a government institution, the object of which is to give students an opportunity of receiving a thorough mathematical training, as preparatory to admission to various branches of the public service, and especially such as call for this kind of preparation for their successful pursuit. These branches are the artillery, the engineer corps, the hydrographical corps, the mining corps, the corps of roads and bridges, the general staff, the telegraphic service, the manufacture of powder, and the management of the government monopoly of tobacco. The course of the Polytechnic School lasts two years; and the pupils, on finishing it, designate the branch of the public service to which they wish to be admitted, and are appointed, as vacancies occur, in the order of the rank with

which they are graduated after the final examinations have been passed. From an inspection of the records for some years back, it would appear that the students who stand highest are inclined, in a considerable majority of cases, to select the mining corps in preference to any other department of the service. The instruction in the Polytechnic School is not exclusively mathematical, although this class of studies largely predominates. Physics, chemistry, German, and drawing are among the other subjects taught. The "élèves ingénieurs," after two or three years at the École des Mines, on passing the required examinations, become "ingénieurs des mines," and are immediately employed in the government service, the nature of their work being exceedingly varied and important, since they have to represent and advise the government in all matters connected with the concession and working of mines and quarries, as well as the building and management of railroads and steam motive-power in general. The scientific investigations of the "ingénieurs des mines" are given to the world in a periodical forming two thick octavo volumes a year, and published continuously since 1794, first as the "Journal des Mines," and, since 1816, as the "Annales des Mines," the whole forming a series of volumes replete with valuable information relating to mines and railroads, not only in France but throughout the world. The mining statistics are published in a separate work of quarto size, issued once every six or seven years. In these volumes the most minute details of the yield of all the mines in France are given, with a great deal of additional information in regard to the commercial aspects of the mining and mineral interests. For instance, a diagram map is issued, on which, at a glance, can be seen exactly whence each district derives its supply of coal; or, if obtained from more than one source, then the proportionate amount from each region of supply is indicated, so that the facts can be clearly and easily made out by simple inspection.

Under the French law, all excavations for metallic ores, mineral substances, or building materials are divided into three classes, — *mines*, *minières*, and *carrières*, or mines proper, mineral deposits worked by surface excavations, or such as are open to the daylight, and quarries. No mine can be opened or

worked without a government concession, and then only under the strictest supervision on the part of the proper authorities. The proprietor of the surface can open and work a quarry on his own land, without any special interference on the part of the state, except so far as may be necessary to secure the safety and health of his workmen and his neighbors. A surface deposit, worked in a *minière*, may be opened and utilized by the proprietor of the soil, if he sees fit to do so; and, if not, he cannot prevent other properly qualified persons from occupying the premises for that purpose, security being given for the payment of such damages as may accrue. A *mine*, that is, a deposit of ore which has to be worked by underground excavations, cannot be utilized, even by the owner of the soil, without a concession from the government; so that, for all practical intents and purposes, the ownership of ores lying deep beneath the surface is entirely separated from the ownership of the surface itself.

Thus we see that the French government has entire control of the mining interests; that it supports a School of Mining, and takes great pains to have the men who go to it educated in the most thorough manner, giving them a five-years' course, selecting them by competitive examination at the beginning, and only allowing them to pass from the general to the special school of science on proof of extraordinary diligence in their studies. We see, also, that careful record is kept of everything that is done towards the development of the mining interests, both from a scientific and a commercial point of view; that the statistics of mining are published in full, as well as a great deal of scientific material connected with the exploration and working of the metalliferous ores and of all other economically valuable substances obtained by quarrying or mining.

One of the duties of the French Mining Engineers has been, from the time of the institution of the corps, the examination of the geological structure of the country, with a view to the development of its mineral resources. The first attempt at what would now be designated as a geological survey was in 1811. At that time, Brochant de Villiers, professor of geology in the École des Mines, presented to the government a plan for

making a geological map of the French Empire; but, in the troublous times which followed, the work came to naught. In 1822, the subject was taken up again, the immediate incitement thereto being the publication of Greenough's Geological Map of England; and, in 1825, the work was commenced, the gentlemen intrusted with it, all professors in the mining school, having been allowed a year for travelling in England and preparing themselves by the study of the geology of that country. The result of this survey was a map, with accompanying text, published in 1840, after more than ten years of labor. It was on a scale of 1:500,000, in six sheets, which, when put together, made a square of a little over six feet; it was by far the finest work of the kind which had, up to that time, been executed. In 1868, the importance of maps on a large scale, on which details could be given, having become fully recognized, the work was taken up again, and this time on a scale of 1:80,000. One of the peculiar features of the new map is this: that the explanatory text is so prepared that it can be attached to the different sheets as they are issued, either laterally or else by pasting on the back when the sheet is mounted on cloth. Thus map and illustrative text will always be together and ready for use. No less than 1,113 different symbols are used on this map for the purpose of designating every variety of mineral occurrence which can possibly be of economical importance; these symbols are used in addition to the usual geological colors, by which the range and extent of the different groups of strata, under their scientific names, are given. There are also sheets of vertical and horizontal sections, on various scales, to suit the nature of the locality, as well as photographic views.

The course of the Prussian government in reference to mining matters, although differing in some details, is, on the whole, very similar to that of France. The new Prussian mining law dates back to 1866 only; previous to that, the government had for centuries been working itself from darkness towards light, as knowledge became more generally diffused and correcter ideas of political economy began to prevail. Mining is of very ancient origin in Germany, and a large number of our own mining terms have come to us from that country through Cornwall. And there was, for hundreds of years, a triangular con-

test going on there between the sovereigns, the princes, and the people in regard to the rights and privileges of the miner. Many things were done in those early days which would seem strange to us if we had not our own Congress to look to for a parallel. For instance, we find at one time that it was forbidden to increase the number of coal-mines, lest the expense of so many deep workings should raise the price of the combustible! However, it will not be possible to go back to the past and trace the progress of more liberal ideas finally culminating in the present law, which places things on an entirely satisfactory basis. As in France, property in the minerals is distinct from property in the soil. The state makes no claim except to regulate, and receives only a very small proportion of the produce of the mine as a return for the necessary expenses of oversight. Any one can "prospect," or obtain a concession to work a mine, on any one's land, by taking proper steps and paying for the damages. The government, as in France, has a Mining Corps, a school where men are trained to the profession, and takes care that nothing shall be done which shall tend to cripple or waste the resources of the country. A quarterly journal is published, with a folio atlas of plates, in which the statistics of all the mines in the empire are given with accuracy and in the greatest detail, and all important improvements in mining and smelting discussed. This publication, as a whole, stands at the head of what is now doing in this line, the French "Annales des Mines" having decidedly fallen off in value within the past few years. A great part of the Prussian territory has, from time to time, been geologically mapped, under authority of the government, and a bureau of geological surveys, the "Landesanstalt," is now fully organized, and the publication of a series of maps on a scale of 1 : 25,000 has been commenced. An immense impetus has been given to the mineral industry of Prussia by borings and other explorations made under the directions of the state, and which have resulted in important discoveries leading to the establishment of entirely new branches of manufacture, based on the occurrence of economically valuable mineral substances existing in immense quantities, but which lie far beneath the surface, and would never have been discovered had it not been for the costly un-

derground researches made in accordance with the indications furnished by a study of the geological structure of the country. In no country has the economical value of this kind of scientific work been more clearly demonstrated than in Prussia; and it may be mentioned in this connection, that it is there that the earth has been penetrated by boring to the greatest depth yet reached by man, namely, a little over 4,300 feet.

In Great Britain the relations of the government to the mining interest are much less direct than on the Continent, and are, in the main, limited to police regulations, having for their object the safety of the men employed and the limitation of the hours of labor for women and children. England and Scotland are countries, however, where mining is a business of immense importance, as will be easily understood when it is mentioned that the make of iron amounts to 7,000,000 tons, and the product of coal to 125,000,000 tons per annum. And in the mining and smelting of the ores of lead, copper, zinc, and tin, England has a vast amount of capital employed. And as Great Britain stands first and foremost of all countries in the magnitude of her metallic and mineral developments, so the government has, especially within the past quarter of a century, been very active in promoting a scientific investigation of these interests, and in putting them on a substantial basis of accurate knowledge.

The geological survey of the United Kingdom began, in connection with the ordnance survey, by the employment of De la Beche to make an investigation of the important mining district of Cornwall and Devon. This was in 1835, and his report was published four years later. Soon the value of the work became apparent, and a separate organization was determined on for the geological survey, which has ever since been carried on with activity. The collections of the survey increased rapidly in importance and interest, and in 1851 the magnificent building in Jermyn Street, in which these collections were deposited, was opened to the public. Here, too, a mining school was established on a liberal scale, so that the Survey, the Museum of Practical Geology, and the Mining School are all parts of one harmonious whole. The work of the survey is carried on at the same time in England, Scotland, and Ireland by corps in a

measure independent of each other, but all under one director-general in London. The publications are already very numerous, comprising geological maps, sections, and printed volumes, all made with the most scrupulous accuracy, and on a very large scale. The ordinary sheets are on the one-inch scale; the coal-fields are laid down on the scale of six inches to a mile. While the cost of an entire set of the publications of the survey is necessarily very large, any one may have a geological map of a region in which he may be specially interested, and the necessary descriptive and illustrative text, for a few shillings. The statistics of the produce of all the mines, as well as detailed plans of the same, are kept at the Mining Record Office, and a full abstract of them published every year.

When we turn to inquire what has been done and is now doing in our own country in the way of developing our mining interests, by geological surveys, mining schools, and the like, we have, in the first place, to distinguish between State and United States authority; and we will first notice the relations of our general government to mines, mineral lands, and mining education and development.

The United States being now, or having been, as has already been set forth in the first part of this article, the owner of most of the territory outside of the older States, that is, of nine tenths of the whole country, has had, of course, the right to control the mining interests, and either to sell or lease any portion of its territory; although that the government has had the power, was perhaps not quite so clear. The first action of Congress seems to have been in 1807, when the government lead-bearing lands in the Mississippi Valley were ordered to be reserved from sale, and the granting of leases was authorized. None, however, were actually issued until 1822; and but a small quantity of lead was raised previous to 1826, from which time the production of this metal began to increase rapidly. For a few years the rents demanded by the government were collected with tolerable regularity; but soon large amounts of mineral land began to be fraudulently taken up as agricultural; and, the miners refusing to make any further payments of rent, the government was quite unable to force them to do so. It was therefore, in 1847, found necessary to do away with

the leasing, and to allow the lead-bearing lands to be sold, since they had been a source of constant embarrassment and of no profit while the leasing system was in force. Exactly the same thing was done in the Lake Superior country, after the lands lying to the south of that lake had been ceded by the Chippeways. The copper-bearing ranges, and a great deal of barren country besides, were covered with leases obtained from the War Department, each of which included at first tracts of nine square miles, and afterwards of one. This issue of leases, however, was suspended in 1846, as being illegal; and in 1847 Congress passed an Act authorizing the sale of the lands, regardless of whether mineral or not; and a geological survey was authorized at the same time, for the purpose of designating what tracts should be sold as mineral land, the price of this being fixed at double that of the agricultural.

A problem of much greater magnitude came up for solution when it was discovered that a large portion of the remote and, as it was supposed, desolate region west of the Rocky Mountains contained more or less of the precious, as well as of other, metals; while over an area of considerable extent the amount of gold to be had by means of entirely unskilled labor was quite unprecedentedly large. A commissioner was sent to California to report on the matter, — a politician, of course, — and he enlightened the world with curious theories as to the origin of the gold in the detritus, but could afford little help to the government in reference to the way in which a small percentage of the gold which was being carried off from the public lands at the rate of sixty or seventy millions a year should find its way into the treasury of the country. It was quite plain, however, to most persons, that nothing could be done, except to wait until conditions changed, or the gold was all carried off. The miners were a too powerful body to be interfered with; and if an army had been sent to California to coerce them into paying, the soldiers would themselves have turned miners, thus only increasing the difficulty. The let-alone policy was therefore strictly adhered to, and for nearly twenty years after the first discovery of the gold by the Americans nothing whatever was done either toward selling or leasing the auriferous tracts, or regulating the ways and doings

of the miners thereon. The diggers, of all nations, occupied the land as if it were their own. They made such rules and regulations as suited themselves, — a new set for each new district; and when they disagreed they fought it out, with a good deal of help from the lawyers, and occasional appeal to the revolver or the Henry rifle as the least expensive and most satisfactory way of getting judgment. When, however, the placer diggings began to be pretty much exhausted, portions of the river-beds having been worked over as much, in some instances, as a dozen times, and at each time with diminishing profit; when quartz and hydraulic mining, requiring perseverance and a good deal of skilfully invested capital, came to be the chief methods of mining; and, especially, when it began to be found desirable to dispose of mines of doubtful value to foreign capitalists; — then it gradually became apparent to mining men that it would be convenient to have a title, and that a position from which one could not be ousted by force, nor by the changing whims of a new body of occupants of the adjacent soil, might be a desirable thing, even if a small sum had to be paid to the United States in return for these advantages. Thus, at last, after years of discussion, pro and con, and when the discovery of the silver-bearing veins of Nevada had quite thrown the gold of California into the shade, making permanency of occupation of the highest importance, Congress took up the matter of the sale of the public mineral lands in the Pacific States; and, in 1866, almost twenty years after the first discovery of gold in California and the consequent rush of emigration thither, an Act was passed entitled "An Act granting the right of way to ditch and canal owners over the public lands, and for other purposes," the "other purposes" being much the most important ones, and including, among other things, provisions for the sale of the mineral lands. This Act was somewhat amended in 1870; and, in 1872, another one was passed, entitled "An Act to promote the development of the mining resources of the United States," modifying and repealing a part of former laws on this subject, and leaving the matter nearly in this form: "All valuable mineral deposits in lands belonging to the United States, both surveyed and unsurveyed," are declared to be free and open to exploration and

purchase by citizens of the United States and those who have declared their intention to become such, "under regulations prescribed by law, and according to the local customs or rules of miners, in the several mining districts, so far as the same are applicable and not inconsistent with the laws of the United States." Mining claims, "upon veins or lodes of quartz or other rock in place bearing gold, silver, cinnabar, lead, tin, copper, or other valuable deposits heretofore located," shall be governed as to length along the vein or lode "by the customs, regulations, and laws in force at the date of their location." But any claim made after the passage of this Act must not exceed 1,500 feet in length on the lode, or 300 feet in width, neither shall it be less than 25 feet in width on each side of the middle of the vein. All persons already holding claims are confirmed in possession of them; but their sides are limited by vertical planes; that is, the idea of "square claims" is maintained, and not the old Spanish custom of regulating the inclinations of the sides of the location to correspond with the dip of the lode. This is a most beneficial provision, and its enforcement by law years ago would have saved millions squandered in litigation; the "honest miner" having been very much inclined, if he had lost his vein, to endeavor to get hold of another, under the pretence that it was one of the "spurs, dips, or angles" of his own, — to use the jargon in which the notices of mining claims have always been written, excepting in the very few districts where "square claims" have been adopted by the miners. Provision is also made for enabling any miner to purchase and procure a patent for his claim, on paying for its survey, and at the rate of five dollars an acre for the land. In case of adverse claimants to the same piece of ground, the question of right has to be settled "by a court of competent jurisdiction." The miner, however, need not purchase, unless he sees fit to do so. The United States will not in any case molest him in his occupancy of the ground. This is not the place to go into any discussion of the crudities of the law in question, which bears all the marks of having been drawn up by lawyers with an eye to their own business, rather than to the good of the miner or of the country in general: certainly no competent mining-engineers could have been

consulted in its preparation. By a subsequent Act, passed in 1873, "vacant coal-lands" are allowed to be entered at the price of ten dollars per acre, "if more than fifteen miles from a railroad, and twenty dollars if within that distance." The amount which may be so entered is limited to 160 acres for each person applying, or 320 in case of an "association of persons." Those actually in possession of coal-mines which they have opened and worked have the preference in making the entry, and may purchase an amount of land not exceeding 640 acres, provided as much as $5,000 has been expended on the development of the property.

In regard to the collection of mining statistics, something has been attempted to be done by the government, but with little success, since there are no laws requiring owners of mines to keep any record of their operations, or to furnish such, if kept, to a government official. The census mining returns, gathered every ten years, have sometimes been amusing from their absurdities, never of any value as statistics, except perhaps in the case of the census of 1870, with reference to the production of coal and iron.* To illustrate the utter worthlessness of our government mining statistics still further, it may be added that the "commissioner of mining statistics" reported, as the gold and silver product of the year 1870, the sum of $61,500,000; the census returns of the same year give as the value of the "gold and silver mining product," $26,452,652. Everybody posted in mining statistics knows that they are of little or no value, unless the sources from which they are obtained are under constant and efficient control by men of honesty and intelligence. In this country estimates of the amounts of the metals produced are simply guesses, which are valuable in proportion as the guesser has skill in weighing against each other and combining a great many facts bearing indirectly on the problem to be solved.

* The superintendent of the census of 1860 estimated the amount of iron produced in the United States at 98 pounds for each man, woman, and child. To arrive at this result he added the total production of manufactured iron to that of the crude pig from which the manufactured was almost exclusively produced, — a proceeding exactly similar to what it would be if, to ascertain the weight per head of bread consumed in any town, one were to add the weight of the flour sold to that of the bread produced in order to arrive at the total to be divided by the number of persons.

The establishment of a national mining school, under the control of some one of the departments at Washington, has been repeatedly advocated, and bills have been introduced in Congress with that end in view. As our government does not attempt in any way to interfere with or control the mining interest, it is difficult to see why a mining school should be supported by the nation, any more than a school of law or dentistry. The graduates of such a school would stand no more chance of employment than would those of any other institution. It is extremely desirable that our mines should be worked with skill and economy; but the establishment of a national mining school would not have the slightest effect in bringing about the wished-for result. It is very desirable that Congress should pass laws regulating the sale of the mineral lands in a manner consistent with the well-established principles of political economy, and that a sound knowledge of geology and mining should form the basis of those laws. But if the most accomplished and the most honest mining engineers in the country were to offer their gratuitous services to the authorities at Washington for the purpose of helping to draw up the necessary laws, they would simply be laughed at for their pains.

It must not be supposed, however, that because the general government has wretchedly mismanaged the mineral lands belonging to the public domain, that our mining resources have not been rapidly and extensively developed. Our produce of iron is enormous, second only to that of Great Britain: the increase in the amount of coal mined is rapid, and indicates the steady expansion of our manufacturing interests. The gold of California has been washed from the surface detritus with feverish haste; and now the silver-mines of Nevada are the scene of the most extensive mining operations the world has ever seen. Nature has been prodigal in her gifts to our people; and we have been and are, perhaps, not more wasteful of our mineral than of our agricultural resources. The future will show how haste has made waste; but there is not the slightest reason to expect any change at present. As the development of the great permanent mineral interests, those of coal and iron, is chiefly in the older States, where the gen-

eral government has no claim to interfere, having no ownership in the land, we may expect to see the individual States, at no very distant period, making necessary and desirable regulations for the health and safety of the miners and the people living in the neighborhood of underground workings; and economy, the result of skilful management, will come into fashion when the country has been forced into it, — a process which, as some think, has already commenced. A thorough knowledge of the geological structure of the country will form a sound basis on which the economical development of its mineral resources may rest; and of what has been done in this direction by United States and State authority we may now proceed to furnish a sketch.

The first step in geological science in this country dates back as far as 1807, when William Maclure, quite unaided and alone, commenced the exploration of the structure of the Appalachian chain, and the region lying between that range and the Atlantic coast. This was before William Smith's Geological Map of England had been issued; but this pioneer in the science had already, seventeen years before, given to the world his "Tabular View of the British Strata," in which, for the first time, any part of the series of fossiliferous rocks, which make up so large a portion of the visible crust of the earth, had been arranged in the order of their formation. The Geological Society of London had just been founded, and the science of geology had suddenly begun to exist, and to command attention among educated men throughout Europe. Unfortunately the rocks of which the order of superposition was first worked out in England were quite different in geological age from those which largely predominate on the Atlantic slope and in the Valley of the Mississippi. Had this been otherwise, had the Silurian and Devonian formations, which cover so large a part of our own territory, been equally important and well defined in England, the task set before the earlier explorers here would have been much simplified. As it was, they had to wait for thirty years before Sedgwick and Murchison solved the difficulties presented by the Palæozoic system in Wales and on its borders, and gave our geologists the material for comparing their results with

those which had been obtained elsewhere. It was no wonder then that Maclure found himself involved in a maze of difficulties: the work he had undertaken was far too comprehensive for any one man to accomplish. His geological map, however, did roughly indicate the character of the formations over an extensive area; and, considering the circumstances, it may be said with truth that this first step was one which should be remembered as a worthy beginning of American geology. An "American Geological Society" was formed in 1818, under the leadership of Maclure, although its existence was but short-lived; and the same was the case with the "Pennsylvania Geological Society," which was originated in 1832. The "Mineralogical Journal" of Dr. Bruce, also of brief duration, and the "American Journal of Science," established by Professor Silliman in 1818, which has held out up to the present time, were indications of incipient activity in the direction of mineralogical and geological research. Amos Eaton was the first person in this country to make what we should now call a "geological survey," that is, a detailed examination of some special district, with a view to the elucidation of its geological structure and mineral resources. This survey was of the route of the Erie Canal; it was paid for by Stephen Van Rensselaer, and the results published in 1824. Here again the same difficulty presented itself which met Maclure; the rocks and fossils were unlike those best known in England, and the puzzle was so complicated that one man, in a short space of time, could do almost nothing towards its unravelling. There was but little accomplished except to call attention to some of the most prominent varieties of rocks, without any attempt to find out much about the fossils they contained, the science of palæontology being then indeed in its infancy. At the time when Eaton's work was done, the mining and smelting of iron ores had already become of very considerable importance, our yield of pig-metal reaching, in the year 1830, 165,000 tons; anthracite coal was beginning to come into general use, the Lehigh region supplying the market exclusively from 1820 to 1825, while the Schuylkill and Lackawana districts were opened between 1825 and 1830, when the quantity mined had risen to nearly half a million tons per

annum. The smelting of lead was also just becoming a business of importance in the Mississippi Valley; but there was little else worthy of notice doing in the way of the development of our metalliferous resources. The discovery of gold in the surface detritus had, however, created a great excitement throughout the Atlantic States from Virginia south; and no doubt this was one of the principal causes of the sudden rise into prominence of geological and mineralogical studies in this country, and of the starting of a large number of State surveys just about this time.

A recognition of the science of geology by the general government seems to have been first made by the appointment of Mr. Featherstonhaugh, an Englishman, "to examine geologically the Territory of Arkansas and the adjacent public lands," which, at that time, in 1834, namely, might be taken to mean almost any part of the Mississippi Valley. This gentleman, who took the title of "United States Geologist," examined the country and published a geological section extending from the Atlantic Ocean, through Illinois and Missouri, to Texas; but his printed report contains hardly anything of value. All the limestones of the West were grouped by him in one formation, which he considered to be identical with the English carboniferous. His work was but little, if at all, in advance of that of Eaton, done ten years earlier, while the science had in that time made great advances, especially in England.

In 1839, Congress passed a resolution requesting the President to prepare "a plan for the sale of the public mineral lands," and also to cause surveys to be made for the purpose of getting information "relative to their location, value, productiveness, and occupancy." From the documents published the next year, it would appear that no other mineral lands were intended to be embraced in this inquiry than those of the Upper Mississippi Valley. The idea of mining any farther west than this was hardly dreamed of at that time. At least, it seems to have been expected that the work of exploration would be completed within three or four months, and Dr. D. D. Owen was appointed "principal agent" for that purpose. His report, made early in 1840, was limited to the lead region of Wisconsin, and contained the first approximate indication of the out-

lines of the geology of that State to the south of the river of the same name, and also of Northeastern Iowa. At this time considerable progress had been made in working out the geology of New York and Pennsylvania, and it was not difficult to take a long step in advance of Mr. Featherstonhaugh; so that the rocks of the region in question were correctly referred to the Silurian system, and the natural groups into which they were divided were indicated with considerable accuracy.

A few years later, namely in 1847, the subject of the disposition of the public mineral lands was again before Congress, and this time with reference to the copper region of Lake Superior, about which there was great excitement throughout the country from 1844 on for several years. On this occasion two new geological surveys were ordered, one of the Upper Peninsula of Michigan, — the Lake Superior Land District, — the other of the Chippeway Land District, embracing an extensive area in Wisconsin, Minnesota, and Iowa. The results of both these surveys, accompanied by maps on which the tracts designated as mineral lands were indicated, were published in 1850 – 52, and were much more elaborate in their character than anything which had been previously done in this way by the general government. The geological formations were marked out and classified, over that extensive area, essentially in the way in which they now are, later surveys having made but few additions except of details. The great extent and value of the iron region of Lake Superior were then, for the first time, made known. These surveys did not, however, as has been shown already, lead to any general plan for the disposition or the care of the mineral lands. It was not until nearly twenty years later that this was attempted.

After the discovery of the gold of California, which happened just about the time that the Lake Superior speculations, or the "copper fever," as it was generally called, had subsided into comparative quietude, the attention of the government began to be more and more called in the direction of a West, a long distance farther off than what had been previously known as the "Far West." When the importance of the mining interests of California had been demonstrated, — and this needed but a brief space of time, the yield of gold rising almost immedi-

ately to figures entirely unparalleled in the world's history,— it might naturally have been expected that Congress would set on foot a careful reconnoissance of the region west of the Rocky Mountains, a region of a million of square miles nearly, absolutely unknown, so far as its geology and mineral resources were concerned, but which, judging from what had long been known of Mexico, of whose Cordilleras ours were evidently the continuation, might be expected to be pre-eminently the mining region of the country. Nothing of the kind was done. Our legislators seemed entirely unable to grapple with any of the problems presented in that exceptional region. Each of the Pacific Railroad surveying parties, as already mentioned, was accompanied by one or more persons whose duty it was to collect in all departments of natural history, and to study the geological structure of the regions traversed. Owing to the inexperience of most of the observers, and the rapidity with which the vast area was explored, almost nothing was accomplished in the way of throwing light on the mineral resources of the country west of the Rocky Mountains. Hardly one of the important problems presented in the field of general geology was solved. What was done was almost exclusively along the Pacific coast, the Rocky Mountain ranges and the great interior basin between them and the Sierra Nevada having been quite neglected. Hence it was, that up to the time of the commencement of the California State survey, no evidence had been obtained with regard to the age of the auriferous rocks of the California gold region; neither had it been discovered that the rocks about San Francisco were of Cretaceous age; and the very existence of this member of the series was quite unsuspected, although it forms the main body of the Coast Ranges, from Monterey north, and also occurs in large isolated areas on the flanks of the Sierra. Moreover, there was nothing known of the geological position of the high gravels worked for gold by the hydraulic process; nor had anything been discovered in regard to the occurrence of the Alpine Trias over a vast area in Western Nevada, a group of rocks extending from Mexico to Alaska, and replete with that peculiar assemblage of organic forms which has attracted so much attention in Europe. Indeed, nothing had been made out about either the geological

age or the structure of any part of the Great Basin beyond what the collections made by Fremont had revealed. And in the Rocky Mountains proper, — the eastern edge of the Cordilleras, — all was entirely a *terra incognita* so far as its structure and the nature of its fossiliferous groups were concerned.

Our knowledge of the geology of the "Great Northwest," as the vast region of the Upper Missouri at the base of the Rocky Mountains may be called, has been developed gradually, beginning with the days of Lewis and Clarke. These pioneer explorers brought back with them fossils enough to enable Morton to determine the existence of the Cretaceous series in that region, and twenty-five years later Prince Maximilian of Neuwied obtained additional evidence of the same fact; and again, in 1839, Mr. Nicollet acquired some information with regard to the magnitude of the area over which these rocks extended. The first knowledge of the wonderful Tertiary fauna of the region of the so-called "Bad Lands" — the Mauvaises Terres of White River — was obtained by means of a bone sent in 1847 from one of the posts of the St. Louis Fur Trading Company to Dr. H. C. Prout of that city. The region was explored, ten years later, by one of Dr. D. D. Owen's assistants, who was then engaged in the survey of the Chippeway Land District, as before noticed. The fossils thus obtained, and those afterwards brought from that region by Mr. Culbertson, and other collectors, were described by Dr. Leidy, and proved to be of the greatest interest.

In 1853 two gentlemen visited the Mauvaises Terres, whose names are identified with the progress of geology in the Northwest, namely, the indefatigable explorer, Dr. F. V. Hayden, and the eminent palæontologist, Mr. F. B. Meek. This expedition, which was made at the expense of Professor James Hall, laid the foundation of our knowledge of the geological structure of that region; and almost the whole of what we now know of the geology of the Rocky Mountains is based on the work carried on or superintended by Dr. Hayden, almost uninterruptedly since 1853, and during most of the time under the authority of the Department of War or of the Interior at Washington. Those who are acquainted with the progress of American geology will not need to have it stated that the value of Dr. Hay-

den's work has been greatly increased by the thoroughly trustworthy and conscientious manner in which his extensive collections of fossils have been worked up, not only, and chiefly, by Mr. Meek, but also by Messrs. Leidy and Lesquereux. Dr. Hayden accompanied the expeditions of General Warren and General Raynolds, to which allusion has already been made, and in which the region of the Upper Missouri and the Yellowstone was reconnoitred. These explorations were followed by the appropriation by Congress of a small unexpended balance, made originally for defraying the expenses of legislation in Nebraska, for the purposes of a geological survey of that Territory. Under that authority Dr. Hayden was appointed United States Geologist in 1867; and the appropriation was renewed the next year, with directions that the survey should be extended into Wyoming, and, if time permitted, as far as the South Park in Colorado. The work thus begun became first the "United States Geological Survey of the Territories," and later, as already mentioned, the "Geographical and Geological Survey of the Territories." Under this organization, the geological corps being reinforced by a topographical one, the work has gained greatly in scope and value, the appropriation having been liberally increased in amount; so that, if the organization could be made a permanent one, and not be, as it is, absolutely dependent on the whim of each successive Congress, we should have reason to look forward to a most satisfactory working up of the topography and general geology of the Cordilleras. Some geological work has been done in connection with Major Powell's survey of the Colorado, and the Wheeler Survey, under the United States Engineer Bureau, to which allusion has already been made; but nothing of importance has yet been published by either corps, so that no judgment can be formed in regard to the method or value of the work. The remarks made in reference to the manner in which the Departments of War and the Interior are duplicating each other's topographical work applies equally to the geological. The last volume of Hayden's Survey — the Annual Report of the explorations of the year 1873 — shows a gratifying advance over the preceding ones, in respect to the real value and accuracy of the geological material it contains.

The geological results of the "Fortieth Parallel Survey," in charge of Mr. Clarence King, are not yet published; but it is understood that one or more volumes are well advanced towards completion, and that they will soon be issued. We confidently expect to find in them a very large amount of new material of great importance, as throwing light on the structure of an extensive area, which Mr. King, with the large means put at his disposal by Congress, and the aid of an excellent corps of assistants, has had a fine opportunity to work out in considerable detail. The volume of "Mining Industry," published three years ago, and chiefly devoted to the detailed description of the most important mineral vein in the world, — the Comstock lode, — is a superb piece of work, and far in advance of anything previously done in this country in the same line, and we know of nothing published in Europe superior to it. And it should not be forgotten that the high character of the work done by the Fortieth Parallel Survey was the cause of a great advance in the methods and aims of the other surveys which have their headquarters at Washington. This was especially the case with regard to Dr. Hayden's work, with which Mr. King's chief topographer, Mr. Gardner, and some of his assistants, became connected, thus rendering it probable that some degree of uniformity would be maintained in the extension of the topographical surveys which from that time forward became an essential part of what was previously only the "United States Geological Survey of the Territories"; that is, a geological survey without any geographical basis.

Of the various geological surveys instituted during the past fifty years by the individual States, it will not be possible to speak in detail. But this can be said, in regard to them all, that they are only reconnoissances. There is not one which rises to the standard of the European surveys, or which is based on an accurate geographical map. Neither has any such survey been made as can be looked on as a finality, or which is so considered by the people. For instance, not one of the coal-bearing States has carried its survey to such an extent of accuracy as is necessary in order that the quantity of this all-important material existing within its borders may be known even approximately. In no State has the economical value of

its metalliferous ores been satisfactorily worked out. Neither is there one in which the character and distribution of the soils and superficial detritus have been made a subject of careful study, as has been done in Holland and is now doing in Prussia. The reasons for this condition of things may be discussed after a brief sketch of the development of these surveys in the different States has been given.

As it is generally stated that North Carolina was the first of the States to conceive the idea of having its mineral resources investigated at the public expense, it may be well to state that the idea originated (in 1821) with a Connecticut schoolmaster, Denison Olmsted, who was then acting as Professor of Chemistry in the University at Chapel Hill; and it may also be mentioned that the — not overpowering — sum demanded for the work, namely one hundred dollars, was never received from the State treasury; so that the credit, if there be any, must be fairly set down as belonging to Connecticut rather than to North Carolina. The report itself was as creditable a one as could have been expected under the circumstances. Considerable information was collected in regard to the occurrence and value of the ores, minerals, and rocks of the State. The Deep River coal-field and the sandstones accompanying it were described, and referred pretty nearly to their true place in the geological series.

Something similar was attempted about the same time in South Carolina, but the results were never published, except in the form of communications to the newspapers. The geologist employed, Lardner Vanuxem, a native of Philadelphia, was — so far as is known to the writer — the first American educated abroad to the profession of mining engineer; and his scientific training stood him in good stead, a few years later, when he took charge of one of the districts into which the State of New York was divided, for the purposes of a geological survey. At this time the number of persons in the United States who had received what we should now call a scientific education must have been exceedingly small. There was no institution in the country where anything more than the rudiments of chemistry, mineralogy, and geology was taught; and it appears that there were only two or three persons,

among all the earlier State geologists, who had had the opportunity of pursuing these studies in Europe, so that the first business of most of them, on entering upon their respective fields of labor, must have been to teach themselves.

Massachusetts was, in point of fact, the first State to inaugurate a geological survey, the beginning of the topographical work already mentioned having been very soon followed by the appointment, as State Geologist, of Rev. Edward Hitchcock, a gentleman who had become known through various papers in the " American Journal of Science " relating to the geology of the Connecticut River Valley. This appointment was made in 1830, and the work went on, with some stoppages, for about ten years. What was at first intended as a final report was published in 1833; but a re-examination of the State was then ordered, and the completed work was issued, in two quarto volumes, in 1841. This was followed by a long series of publications, issued by the various States, the volumes having succeeded each other rapidly, until now quite a library of them has accumulated. Between 1833 and 1836 nearly every one of the Eastern and Middle, and several of the Western, States commenced their geological surveys, — first Tennessee, then Maryland, followed by New Jersey, Virginia, Pennsylvania, Ohio, Michigan, Indiana, Kentucky, and several of the smaller States. In few of these cases did the work go on to what was, even then, considered a satisfactory completion; in most instances it was stopped after one or more annual reports had been made. New Jersey was for a time satisfied with Professor H. D. Rogers's final report, published in 1840; but the work has, since then, been several times taken up, and now the geological survey seems to have become a fixed institution in the State. The present State Geologist, Professor G. H. Cook, has annually, every year since 1868, made a brief report on some special subject of economical importance to the people. The earlier surveys of Ohio, Kentucky, Indiana, Michigan, Virginia, and Tennessee, in fact of all the large States except New York and Pennsylvania, were abandoned, and before anything like a complete reconnoissance had been made. In all these States, however, with the exception of Virginia, the abandoned surveys have been taken up again, and in some

cases there have been several renewals and stoppages of the work.

Of all the earlier State surveys, those of New York and Pennsylvania were the only ones which became of considerable importance, and really contributed in a marked degree to influence the development of geological science in this country. These surveys were both begun in 1836, that of Pennsylvania being strictly limited to geology; while in New York several branches of natural history, as well as agriculture, were to be made the subjects of special reports. New York is a State of large area, rich agriculturally, and having great manufacturing resources. For her coal, however, she has to depend on her neighbors in the South and West, as she has, herself, no workable deposits of that invaluable material. Mining is of very secondary importance in New York, as the only metalliferous ores which have been hitherto worked with profit are those of iron. The manufacture of salt from the brines obtained by boring in the central part of the State has, however, long been an important branch of industry. Hence the economical aspects of the geological survey were of secondary importance, and the particular interest attaching to the work was due to the fact that here the sequence of the geological formations, from the base of the Carboniferous down to the very bottom of the fossiliferous rocks, including the Devonian and the Upper and Lower Silurian, was first completely worked out in this country, and the fossils characteristic of each group and subgroup figured and described. And since these Palæozoic rocks of New York extend far and wide over the Valley of the Mississippi, — as far as Lake Superior on the north, and to Iowa and Missouri in the south and west, — the volumes of the "Palæontology of New York," by Professor James Hall, which have been issued from time to time since 1847, have been the indispensable guide to our Western geologists, as they have gradually extended the area of their investigations over the interior of the continent. The sequence of the different groups was easily made out in New York, because there they lie conformably on each other, without having been much moved from their original position. In New England, on the other hand, rocks of the same geological age as those of New York cover a

large portion of the surface; but, instead of remaining nearly as they were deposited, they are broken, turned up on edge, and folded, the fossils they once contained having been almost entirely obliterated, and their very inmost structure changed by chemical agencies acting under the influence of heat and pressure. Thus, while all was plain and easy to decipher on the west of the Hudson, on the other side all was doubt and difficulty, so far, at least, as the geological age and position of the strata were concerned. Under these circumstances it has only been by slow degrees, and chiefly by comparison of results attained on our northern borders by the Canada survey, and also, from time to time, by discoveries of little patches of rocks in which the fossils have not become entirely obliterated, that the outlines of New England geology have been made out; and this has been almost entirely accomplished since the publication of Dr. Hitchcock's Final Report.

Although the Pennsylvania survey was begun in 1836, nothing was published, excepting a few meagre annual reports, issued in the first years of the work, until the year 1858, when the Final Report, in three quarto volumes, was given to the world. The engraving and printing of these were done in Scotland, and in a style of great perfection and elegance. But the publication of the results of this survey had been so long delayed that a portion of its value was lost. The nomenclature proposed for the different groups of the palæozoic series never was adopted, that of the New York survey having already become familiar to American geologists; and as no attempt was made to work up the palæontology, except so far as the plants of the carboniferous series were concerned, these beautiful volumes can only be said to have had a local importance, being especially valuable for their details of the coal-bearing rocks, in regard to which a great amount of detailed information was laid before the public. More than any State in the Union, Pennsylvania needs an exhaustive geological survey, based on a thoroughly accurate geographical one. Her coal and iron deposits are on such a scale of magnitude, and of such vast commercial importance, that it is safe to say that the time will surely come when this will be recognized, and the people will demand a style of work equal to that of the best

European surveys. Quite recently, after nearly twenty years of repose, the work of a geological examination of this State has, indeed, been taken up again. It does not appear, however, that this new work is to be based on and preceded by an accurate trigonometrical survey. Unless we are misinformed, it is, on the contrary, to be limited to three years in duration; and already a final report on one important object of investigation, petroleum, is spoken of as being ready for delivery, although it has not come into the hands of the writer. It is safe to say, therefore, that Pennsylvania will yet demand a higher class of work, and it may be that this will become evident to the people, while the present survey is in progress, so that this may be allowed to develop itself until it reaches the desired degree of completeness; if not, the work will surely be resumed at some future time; while the loss thus incurred, by putting off until some distant day the thorough investigation of the resources of the State, although not appreciated by the present generation, will become very evident when the people have become educated up to a proper understanding of these matters. The attempt to supply an accurate map of a small area of the anthracite region, made by private parties, is well as far as it goes; but private surveys can never carry that weight which public ones do, neither can they by any possibility reach the requisite degree of precision, unless limited to a very narrow area.

Virginia, which is also a State presenting a most attractive field to the geologist, — and in making this statement we may include both Virginia proper and West Virginia, — has done nothing in the way of a survey during the last thirty-five years. The detailed study of its topographic and geological structure would be a work of great interest, and could hardly fail to be at once remunerative to the State. Ohio, Indiana, Illinois, and Kentucky, four States which have large areas of coal-bearing land within their borders, and which also possess great agricultural resources, all have surveys in progress, which are more or less continuations of work begun forty years ago and taken up and dropped, in some instances, several times, and under different heads. In Ohio and Illinois the publication of what appear to be intended as Final Reports is

drawing to a close, — the field-work, as it seems, having been finished. In Illinois five large volumes have been issued, which form a worthy supplement to the Palæontology of New York, being chiefly interesting from their contents in this department. Valuable material of the same kind is found in the two published volumes of the Ohio Survey, and a large amount of detail in regard to the coal and iron resources of the State. To thoroughly work out the questions of economical interest which are offered by the great States of the Mississippi Valley will be a very serious undertaking. The surface throughout this part of the country is everywhere only moderately undulating; but the streams — which are very numerous — have cut themselves valleys which vary considerably in depth and width, in different sections. This erosion of the river-valleys, taken together with the general irregular wearing away of the surface by atmospheric causes, and the action, over a portion of the region, of the northern drift currents, have given rise to a kind of topography which requires a very minutely detailed study if the geology is to be laid down with accuracy. And, as the coal-measures often lie quite near the surface, it will be easily understood that the amount of denudation which has taken place becomes a very important element in arriving at a knowledge of their extent and value. The time will come when this detailed work will have to be done; but it is perhaps not to be expected that so extensive and costly an undertaking should be entered upon at once.

From what has been said in the preceding pages, the reader will, it is hoped, have gathered some idea of the nature and scope of a geological survey. He will not fail to have noticed that, as in geographical, so in geological work, the reconnoissance is a very different thing from the thorough survey. And as it is only countries far advanced in wealth and civilization which can have accurate maps of their domains, so it is only those possessing accurate maps which can have their geological work thoroughly done. And the more detailed the investigations which are made in any region, the more practically valuable they are; indeed, it may be said with truth, that it is only work which is detailed and thoroughly accurate that can be trusted and used, where a problem of economical

importance, involving a considerable expenditure of money, is to be solved. The reconnoissance answers the purpose of satisfying the curiosity of the general public, and awakens scientific interest, by opening new problems for investigation; but the capitalist and the miner can only use as a guide that which goes into minute details, giving measures and distances with accuracy.

Another circumstance must be taken into consideration; that is, the necessity of a partial development, at least, of the mineral resources of a country, before much that is trustworthy can be ascertained about their value. It is much easier for the geologist, as for every one else, to see through the millstone after the hole has been bored in it. Indeed, in many instances, the character of the surface of a country is absolutely no guide to what is beneath. What could any one have known of the marvellously intricate structure and wonderful development of the Belgian coal-fields before the rocks had been reached and laid open by shafts and borings carried down through the horizontal, undisturbed strata which overlie the crumpled and dislocated coal-measures beneath, from which that little busy country derives so much of its wealth? The geologist must have his opportunities; and especially the mining geologist, for each mining district has its peculiarities, and these can often hardly be guessed at before they have been revealed by actual working. It is only in the oldest and best-known mineral regions of Europe, where work has been carried on, uninterruptedly, for hundreds of years, that one can feel a tolerable degree of security in giving an opinion in regard to the value of a newly opened metalliferous deposit; and it is there that the importance and value of accurately kept records of previous work are shown to be of so much value. As a contrast to the completeness of our knowledge of what has been done and is doing in Europe, in the way of utilizing the mineral deposits of the various states, let the inquirer consider how little is definitely known of the present resources of Mexico and the South American countries, which have been so productive in the precious and other metals in former days. What a record of ignorance and waste is there displayed, and how wretched the net result to the people!

If our own geological surveys, begun when the science was almost in its infancy, and when, indeed, in this country everything was yet to be learned, have thus far had no considerable immediate practical value, they have been of great importance in the way of developing a taste for the natural sciences, which are all more or less included in the study of geology. And there was no other method by which progress could be made than that of beginning, and doing the best that could be done under the circumstances. The condition of things has greatly changed in this country, since it was thought that the physician could leave his patients, or the clergyman his pulpit, and give an authoritative opinion on the structure and mineral resources of the country. Schools of science are now numerous; and some of them, at least, fairly well equipped for teaching those specialties which are needed for doing good work in geographical or geological surveys. Forty years ago there were, at the most, half a dozen Americans pursuing scientific studies in Europe; now the number may be counted, probably, by the hundred. Could the knowledge and ability we have in the land be economically and judiciously utilized, a large amount of first-class work could be done, and fine results obtained; and that, too, without any considerable increase in the expenditure beyond that which is now habitually incurred.

We come now to make a practical application of what has been said in the preceding pages, and in a previous article on geographical surveys, to the State of Massachusetts. Of what has been already done here mention has been made; and it has been noticed that the matter of a new survey was before the Legislature at its last session, and was the subject of a report from the "State Board of Education," to which the question had been confided for examination at the preceding session. The bill introduced for the purpose of organizing a topographical, geological, and biological survey of the Commonwealth failed to become a law, so that the subject remains open for discussion.

And before commencing an examination of some of the principal points to which attention ought to be given in this connection, it may be well to mention that the area of the State of Massachusetts is usually given at 7,800 square miles, while

the population, by the census of 1870, was very nearly a million and a half of souls, so that we have an average density of 186 to the square mile. In the United Kingdom of Great Britain and Ireland there is an average of 260, in Belgium of 462, to the square mile. In Massachusetts the population is considerably more dense in the eastern than in the western and northwestern portions. The most thinly inhabited part of the State has also the most uneven surface, although there is but a comparatively small area which is too mountainous to be brought under cultivation. Massachusetts is essentially a manufacturing State: according to the last census the value of her manufactured products, in 1870, was nearly $554,000,000, while the figures given for New York — with six times the area and three times the population of Massachusetts — are $785,000,000. The wealth of Massachusetts is only exceeded by that of New York and Pennsylvania, and is nearly double that of New York in proportion to its area. The metalliferous mines of this State are of little importance, but the quarries of building material are extensive; although, as compared with the manufacturing interest, the value of their product seems but trifling. The value of the iron mined was, in 1870, according to the Census Report, $30,000; no other metalliferous ore is mentioned as having been worked in that year in Massachusetts; neither is there a record of any produce of coal. The value of the products of our quarries is given at $1,362,648, or about $\frac{1}{400}$ of that of our manufactures. These are some of the principal data to be kept in mind, while discussing the subject of geographical and geological surveys with reference to the State in question.

It will be admitted by all that if any one of the United States can afford to carry on a thorough survey, it is Massachusetts. The density of her population is considerable, even as compared with that of some of the most thickly inhabited European states; her wealth is great, and the development of her commercial and manufacturing interests has been, and is, rapid. Land is valuable, and is likely to become more so from year to year, and economy and skill are needed in order that a State which has become wealthy rather by means of hard work and indomitable energy, than because she has been boun-

tifully provided with natural resources, may continue to occupy a high relative position, in competition with other portions of the country which have a richer soil and a much greater supply of mineral or metallic wealth.

In considering what kind of a topographical survey is needed, we have to inquire how such a work is utilized after it has been completed, or, in other words, what is the pecuniary inducement for its prosecution. All will admit that it would be unwise to enter upon an undertaking which must of necessity be very expensive, without a clear understanding, at the outset, of the reasons why the expenditure is to be made. Besides, the scale and degree of accuracy of the work to be done depend on the use which is to be made of the results; until this point has been settled, it would be idle to estimate its cost, or to attempt to limit the time of its completion. Now, the principal objects of the great topographical surveys in Europe are: *first*, to furnish the government with the necessary data for fairly and accurately determining and apportioning taxation; and, *second*, to make it possible for transfers of real estate to be made with ease and precision. In other words, the cadastral, topographical, or ordnance survey — by whatever name it may be called — is a part of the machinery of the government, and, as it appears to most civilized states, a necessary part. It is true, also, that topographical maps are of importance on the Continent, — where wars have been, and are likely to be, frequent, — for guiding the movements of armies; but this has been a consideration of little weight in England, and is still less to be taken into account here. The peaceful aspects of the subject need only occupy our attention. In addition to the great and all-important uses to which an accurate topographical map can be put, namely, those connected with taxation and the transfer of real estate, there are many other minor ones, which have already, in part, been suggested in the preceding article on this subject. It can be said with truth, however, that we have had no such accurate surveys as are going on in the different European states, because here the people do not know the uses to which such work is put, while there the government does know. It is, therefore, most reasonable to suppose that, in a country where the people are

the government, the necessary preliminary to such a work as that we are now discussing will be increased knowledge on the part of the people. Let them but once fully comprehend the advantages which such a survey offers, when well done, and they would never be willing to do without it. Let the work be begun without a full understanding, and a settlement by legislation, of the uses to which it is to be put, and the probability is strong that it would be stopped, as soon as a "realizing sense" of its cost began to be felt. Hence we argue that, instead of beginning another Hoosac Tunnel, which is sure to cost a great deal, and which perhaps there may not be intelligence enough in the State to utilize after it is done, the subject of a thorough survey be fully investigated by a competent commission of experts, who themselves have no axes to grind, and who are not looking chiefly to the question of how their own pockets are to be affected by the transaction. Let such a commission, we say, find out by careful inquiry how work of this kind is done in Europe, and how utilized there; and then let them investigate the question whether the conditions in this country are such that it is possible for us to reap the full advantage of so costly an undertaking. A careful discussion of the subject should precede final action.

The crudeness of the Report of the Board of Education is indeed remarkable; and, in looking it over carefully, it is difficult to avoid the conclusion that the members of the Board, knowing nothing practically of these matters, have allowed themselves to be counselled by those who, from motives which it is not difficult to divine, were more anxious to have the work done, than to have it well done. It seems a pity that, after forty years of supposed development and improvement, the Legislature and the people of Massachusetts should find themselves, in reference to the question of a topographical survey, about where they were in 1830, ignorant of the nature and use of the work proposed, misinformed in regard to the methods required for doing it accurately, and led all astray in the important matter of its cost. Indeed, the main object of the report seems to have been to create the impression that the whole thing can be accomplished with but a trifling expenditure; that is, for less than a tenth part of what it is thought

necessary to expend, per square mile of area surveyed, on the Ordnance Survey of Great Britain and Ireland. To make this appear reasonable, it is suggested that the old Borden triangulation can be utilized; and then, it is added, that Congress having provided that the Coast Survey shall "determine the necessary triangulating points in every State which shall make appropriations for a topographical survey," therefore the triangulation can be done at the expense of the United States. Thus it appears that two different triangulations are to be used in the new survey, neither of which is to cost the State of Massachusetts a penny; but how the two are to be combined so as to form one harmonious whole is a problem on which no light is thrown in the Report. The idea is simply an absurdity. Any one acquainted with these matters would recognize the fact at once that the old Borden triangulation could not be used in a new survey, under any circumstances; that, even supposing it were accurate enough, it would be more expensive to determine the position of the old stations than it would be to make new ones; and if Mr. Borden's work is to be made use of, all his stations will have to be occupied again for the secondary and tertiary triangulations, which never were made in the previous survey. The idea, also, that the United States can be relied on to furnish the main triangulation seems to us a delusion. As has already been shown, if the whole amount appropriated by Congress for this kind of work were to be expended in Massachusetts, it would only enable the Coast Survey to carry on the triangulation with a moderate degree of rapidity, and it would certainly require several years for its completion. And does any one suppose that it will be possible to limit to one State only the expenditure of money which is now carefully spread over a dozen or more States, in accordance with the usual method of not favoring one part of the country more than another, when the United States treasury is to pay the bills? Or is it fair to take it for granted that it will be possible to secure from Congress so large an increase of the appropriation for this special purpose as would be necessary in order that a triangulation should be made of the whole country? And, if granted for one year, what security would there be of its continuance during the next? Besides, there are other reasons

why the whole survey, including the primary triangulation, should be done by the State itself; but to enter into a full discussion of the subject would require too much space and too many technicalities, and this must be left for a more suitable occasion. A thorough investigation of the whole matter would settle this, as well as the other points which have been suggested. The recommendation that, for the contour lines, "exact measurements be taken only every one hundred feet, and that the auxiliary lines between them be filled in by the topographer on the spot," might mean something in a mountainous country, where minute accuracy was not deemed essential; but such a style of work is entirely unsuited to the nature of the surface of this State, and the character of the results which will have to be obtained, if the survey is to be one of permanent value, and to be utilized for the purposes set forth in the Report in question.* It is therefore not right or reasonable that the impression should be given that a topographical survey of Massachusetts can be made for $175,000, which is the estimate of its cost made by the Board of Education. The old triangulation, only partially completed, cost nearly half that sum, and it was executed at a time when one dollar meant at least three times as much as it does now.

In regard to the geological part of the contemplated survey, the first thing to be considered is this; that the geology cannot be put upon the map, before the map is ready to receive it. The geological and geographical work cannot be carried on *pari passu*, without loss of time, increase of expense, and liability to error. The painter would not be asked to furnish a picture, unless he had a canvas on which to work. All familiar with geological field-work know that it is impossible to proceed with accuracy and rapidity, except map in hand. The

* To illustrate this, it may be mentioned that in the Connecticut River Valley the points at which the "exact measurements" were taken would be about fifty miles apart! That is, if a hydraulic engineer at Springfield wished to get some accurate information from the State Survey for use at that place, he would find on examination that there was a point, the altitude of which had been fixed with precision on purpose for his convenience, and he would find it — at Greenfield, or possibly at Northampton! And similar conditions will obtain in all our river valleys, where the fall is but slight, and, consequently, differences of level of a few inches will be of the greatest importance.

organization of a geological survey then should be deferred, until some of the sheets of the geographical map are done and engraved; and this must, under any circumstances, occupy several years. But, of all the States of the Union, Massachusetts is one which has least need of a geological survey. This is not a region rich in mineral resources, and it never will be, no matter with how much care its geological structure is investigated. The impression is given in the Report of the Board of Education, that a survey will "develop our coal-fields," and transform us into an important mining community. This is a delusion: if our coal-fields are ever developed, — that is, if their extent and value become thoroughly known, and it be found that they can be worked with profit, — it will be after many and expensive underground explorations have been made by boring and otherwise, and when, so far as we can now foresee, conditions shall have become quite different from what they now are. Previous attempts to make our coal-mines profitable have failed, not for want of means and experience in coal-mining generally, but because the rocks are too much broken up, and the coal-beds themselves too irregular in thickness and position, to make it possible to open and work them without loss.

It is no part of the work of a geological survey to "develop" either coal-fields or metalliferous veins. Development must come from actual working, or from systematic exploration by numerous and expensive borings. That this should be done at the cost of the State would, no doubt, be agreeable to the owners of the land beneath whose surface our coal-fields are presumed to lie; but it would hardly be considered by the people as a legitimate expenditure of their money.

There are within the borders of this State several large and well-defined veins in which argentiferous lead and copper ores occur in considerable quantity. At the time of Dr. Hitchcock's survey, they were considered by him as likely to be "of great value to posterity, if not to the present generation." All the attempts at working them have, however, proved to be unprofitable ventures; although a great deal of money has been spent in this way at various times since 1765. The same has been the case with the other metalliferous veins of New Eng-

land; almost without exception the mines which have been opened on them have been disastrous failures. Eaton, Shelburne, and Warren, in New Hampshire, may be cited as typical localities, where flattering surface indications have led to extensive mining operations, without any permanently valuable results; and it is now many years since these workings were abandoned, with but little chance of being resumed. These facts should be borne in mind by those who are disposed to look on every new discovery of metalliferous ore within our borders as likely to lead to developments of great importance. The experience of the past teaches the necessity of great caution in the expenditure of money on mineral veins anywhere in New England, however flattering may be the surface indications. That wild speculations and hap-hazard investments in entirely undeveloped mines are not likely to be followed by results favorable either to the individuals concerned or the community in general may also be pretty safely affirmed.

The structural geology of Massachusetts is not well understood, nor will it be for many years to come, for reasons which have already been hinted at in the preceding pages. Little by little it will be worked out; but a geologist appointed by the State will have few advantages over those which have been possessed by the ablest men in the profession who have, from time to time, tried their hand at deciphering the puzzle, having no other motive than the interest which it presents to the scientific inquirer. Professor Dana, our ablest structural geologist, has studied the hills of Berkshire, and begun the elucidation of their structure. James Hall, Henry D. Rogers, and others, have done the same. If the Legislature wishes to spend money in this way, let it be done; but it would be wrong to let it be thought that any report on the geology which might be the result of the expenditure would be a finality, so far as the geological structure of the State is concerned, or that it would be of much importance in the way of developing unknown mineral treasures beneath the surface.

It appears to the writer, however, that there is a way in which a State, situated as is Massachusetts in respect to geology and mining, may not only do good service to science, but also receive a *quid pro quo* in the way of valuable informa-

tion on questions of economical importance to the people. All will admit that it is desirable that there should be somewhere in each State a trustworthy source of information in regard to the mode of occurrence and value of the various minerals and metalliferous ores which are, or are thought to be, from time to time discovered. And it is also desirable that a history of the development of the resources of the State, in this department of its industry, should be kept, and such statistics collected as it is possible, under our form of government, to procure. The question arises, how to have a permanent source of information on these subjects, which shall be out of the reach of politics and politicians, where one who does good work will feel secure in his position, and not be obliged to spend a considerable portion of each year in lobbying his appropriation through the Legislature, a humiliating necessity, in connection with our State surveys, which is, of itself, enough to frighten off the best men from having any connection with these undertakings. We would say that the best method of bringing about these desirable results would be, for the State to endow a professorship of economical geology in some institution of learning, that one, of course, being selected which should be deemed likely to keep up the highest standard of honesty and ability among its professors. Coupled with this endowment should be a proviso, that the appointee should report to the executive either annually or biennially, on such subjects connected with the geology and mineral resources of the State as might seem to him to be of the most importance at the time. These reports could be laid before the Legislature, and printed or not, according to their value. If the person selected to fill the position were a man of high ability, no doubt his reports would command attention, and well repay the cost of printing, while their sale would defray a part or the whole of the expenditure. In this way a perennial source of information would be brought into existence, and the amount required for this purpose would not exceed that called for by the Board of Education for a geological survey, which would be limited in time, and, after all, only the expression of the opinions of one person, based on the information obtained during the short period of the continuance of his own work. For it must not be forgotten

that much of that which is considered, in this country, as properly belonging to the business of a geological survey, is work which ought never to be brought to a close. New facts are always turning up, new discoveries are made, commercial and financial conditions change, new uses are found for old materials previously deemed of no value, accumulated experience and knowledge throw light on what was once obscure: all these circumstances indicate that the time will never arrive when everything will be known in regard to the geology of the State, and that it would be wise for the Legislature to recognize this, and make provision for gathering and systematizing the facts as they are developed, and for faithfully doing the best that can be done to make them available to the people.